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NEW PRACTICAL ELECTRONICS

SCIENCE AND TECHNOLOGY

Power To The People

Iridium, a global telephone system

PE takes a look at where all the electricity comes from.

Plus

- CD-I launched early
- The latest mobile phones
- Kyocera's eco printer
- 80Mbyte flash memory
- Europe's new radar lab
- Inside a dimmer switch
- Build a tide timer
- Microprocessor Techniques
- Barry Fox's teletext variations

Canon's electronic camera

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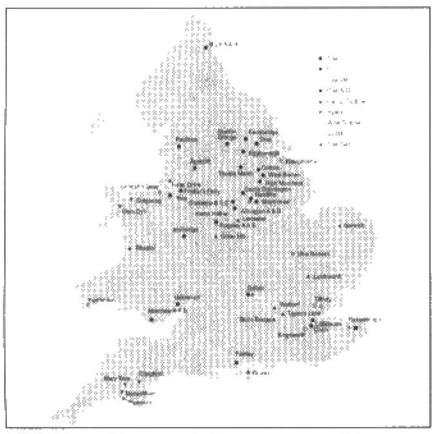
This month...

Multimedia and its glamourous offshoot Virtual Reality have captured the public imagination. The launch of Philips' CD-I system five months ahead of schedule (page 10) and Vistapro (page 23) are just two facets of this craze. As the magazine that brings you the latest in technology, PE will be reporting on the latest developments as they happen.

Also in this month's issue is a look at three new portable telephone systems a new environmentally friendly printer, a new computer storage system and a look at the power generating industry as well as a project to build a tide meter.

Kenn Garroch, Editor



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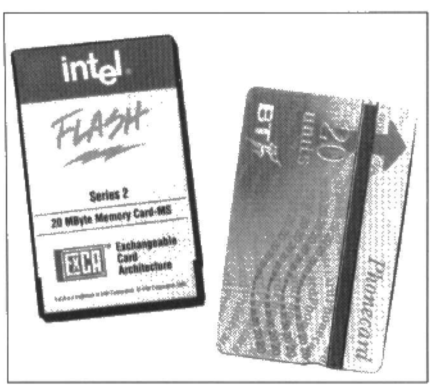

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Electronic engine management, tuning, ICE, electric cars, car power systems, exhaust emission detectors
Out On 2 July

Cover illustration and design: Kenn Garroch

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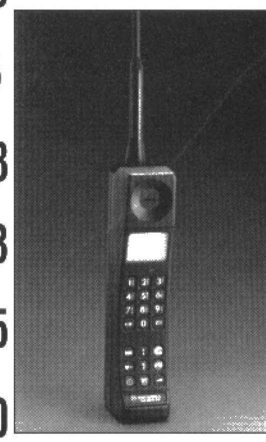

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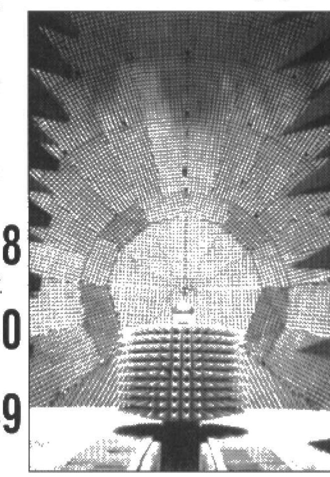
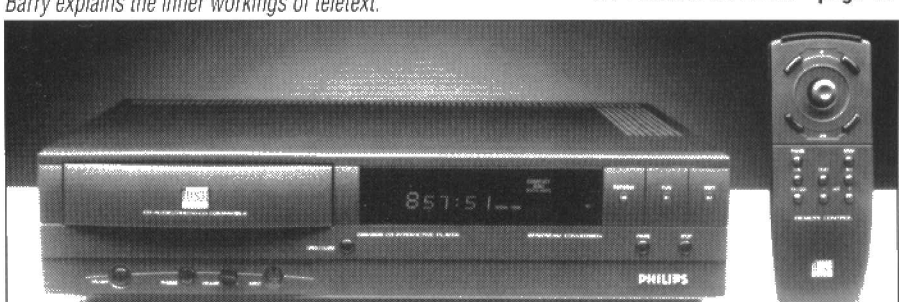


CD-I makes its debut – page 10



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Wavelengths

If you have any comments, suggestions, subjects you think should be aired, write to PE

With regard to recent correspondence regarding a decimal time system, reader's might like to know that Mr. Hanson was quite correct to suggest that the French Revolution as a suitable vehicle to support the introduction of the 10 hour day. Not only did they introduce the decimal system but made gallant attempts to inaugurate a Republican Calendar based on 10 equal months as well as a 10 hour day with each hour divided into 100 equal minutes. The majority of decimal watches to survive from this period have a small second dial which displays the conventional 12 hour day!

J S Foulger
Lakenham
Norwich

3D-TV Was Here

Some 15 years ago I had an idea to create a 3D image on a standard TV without the necessity to create any new technology.

The basic idea was to use two TV cameras arranged spatially to simulate the normal human condition, and to interlace the central portion of the central image. Each image field would have only 5/8ths of it used, for example, the fraction mentioned of the right hand field starting from the right hand edge. The idea was then to remove smaller and smaller vertical slices of image from the "central edge" of each image; the "central edge" of the right hand image being the left hand edge. The lateral scale of the vertical slice was intended to be logarithmic or pseudo-logarithmic, because of the need to interlace the alternate sections of the left and right hand images. The final touch was to have been the application of a film of lenticular plastic, the type used on novelty postcards to get 3D; although the design of the film may have needed to have been optimised at a later date.

I think, in retrospect, that the proportion of each image used would have needed to be variable in relation to the distance of the icon to the centreline of the camera unit.

In conversation with a friend, an electronic engineer, at that time I mentioned the idea but, he did not seem too impressed. Sometime later, the same friend said that he had been to a symposium and that two American scientists presented a paper with an identical idea and that they had patented it!

The writer of the first letter in "Wavelengths" need not feel at all abashed about being taken in by the April fool joke article as, after all, it is such dreams that are the father of all advances. It has been said, that which Mankind can imagine, that can he build!

A P N Beaumont-White
Putney
London

What Do We Want?

Dear Sir,

After reading through the review of the Electronics Workbench in your June issue, I came to the end to find that there was no address or telephone number for the supplier. Could you possibly print this?

J Hoskins
London

Sorry, it got left out, it is as follows: L J Electronics, Unit 5 & 6, Francis Way, Bowthorpe Industrial Estate, Norwich NR5 9JA Tel. 0603 748001

Information

I seem to remember a review in PE of a book about industrial espionage. Unfortunately, I no longer have the relevant back issue (spring cleaning takes its toll). Could you possibly supply the details?

K Williams
Leeds

The book was The Industrial Espionage Handbook by Hugo Cornwall and published by Random Century, ISBN 07126 3634, price £9.99

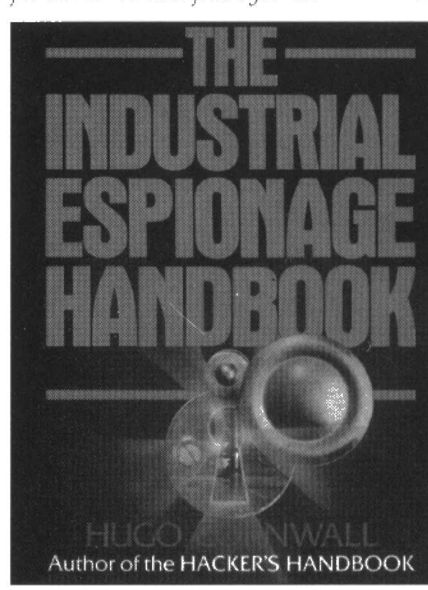
And Phone Numbers

I read with interest Barry Fox's column in the May issue of your magazine. What caught my eye was a snippet of information about being able to search for telephone numbers on a CD-ROM.

I have a PC, modem, printer and the rest but not a CD-ROM. Can I get a list of phone numbers on floppy disk? Is there a dial up number I can call for an on-line service?

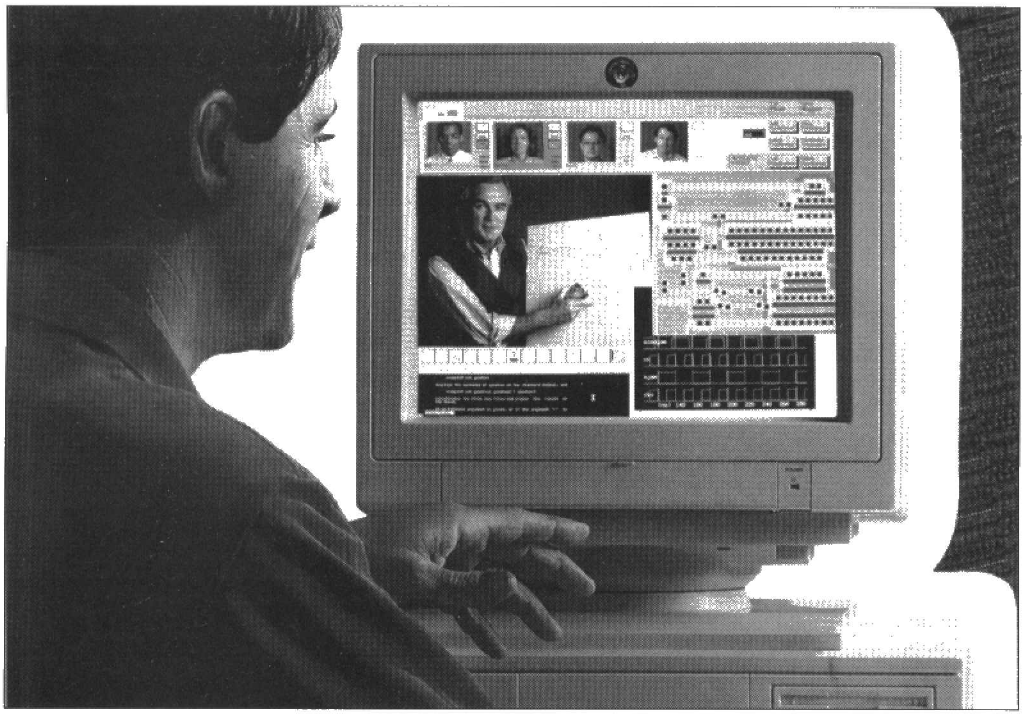
N Parkinson
Manchester

You could try Phonebase, BT's on-line directory service. Freephone 0800 919199 to get details on how to apply for access to this free system. ■



Innovations

This month, the latest in computer wear, sophisticated loudspeakers and IR linked meters.



AT&T now have moving pictures on a PC.

Full Motion Video

AT&T Micro-electronics in the UK has announced a set of chips that will allow full motion video to be incorporated in computer multimedia applications, video-conferencing and point of sale terminals. The three chips comprise an encoder, decoder and system control chip.

Able to handle video at up to 30 frames per second and resolutions of 1024x1024, the AVP-1000 takes care of all the complex data handling and compression functions needed to transmit and receive data at speeds from 40k bits/sec to 4M bytes/sec. Pricing of the system should be cheap enough at under $400 per chip set to allow it to be incorporated into a number of low cost, mass-market products.

For further information contact:

AT&T Micro-electronics on 0344 865927

Sounding Off

UK loudspeaker distributor BK Electronics has just announced three new flight cased loudspeaker systems. Defined as 12in 100W, 12in 200W and 15in 200W, they are all fitted with wide dispersion horns and include grills fitted to the die-cast aluminium chassis. Priced at £159, £175 and £220 per pair including VAT, the speakers are available from BK Electronics, Tel. 0702 527572.

Stack A Chip

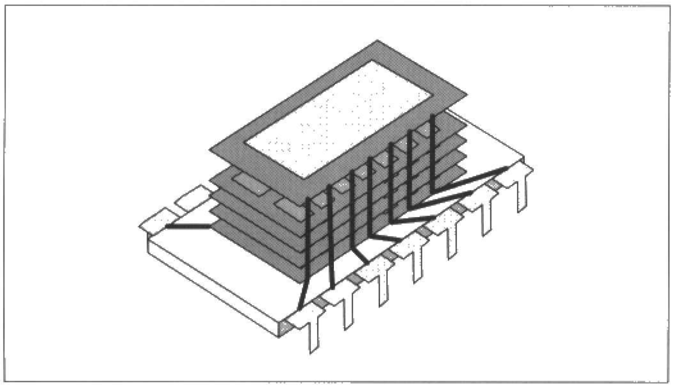
One drawback with current microchip technology is that chips can take up a lot of surface area. An example is the latest memory card systems where the number of surface mount chips fitted on the card is limited by the physical size of the card itself. One solution is to use higher density chips – 1Mbyte say, instead of 128kbyte – but this is limited by semiconductor manufacturing techniques – chips only go up to a certain size.

An alternative solution from the US company Irvine Sensors, is to stack silicon chips into one package. This increases the amount of memory in a given area by a factor of four. The Memory Short Stack uses a technique called Memory Densification by Application of Z-plane Lithography – X and Y planes defining horizontal and Z the vertical. Individual memory chips are connected at the top by a "cap chip" which connects the whole stack up from top to bottom and then to the pins.

IR Meter Link

Levell Electronics Products has announced its new range of digital multimeters. Prices start at £39 for the Voltcraft VC92 with the top of the

BK's speaker set.



Stacking chips – artists impression.

range VC96 costing £65. By adding the VCIR infrared interface, the VC96 can be connected to a computer allowing the creation of a system able to record and display measurements on a PC for under £100. For more information contact Gillian Pugh at Digitron Instrumentation on 0992 587441.

Smart Sounds

Danish Audiophile Loudspeaker Industries, also known as Dali, has recently introduced the Dali 310 high quality loudspeaker into the UK. Based on a twenty-litre, two-way, bass reflex with a 6.5in cast-chassis and polypropylene-coned woofer with 32mm long-throw voice coil, the system also boasts one-inch soft-dome treble drivers with rear venting chamber for low resonant frequency. Hand-built hard-wired crossovers incorporate polypropylene capacitors and air-cooled inductors for optimal sound quality.

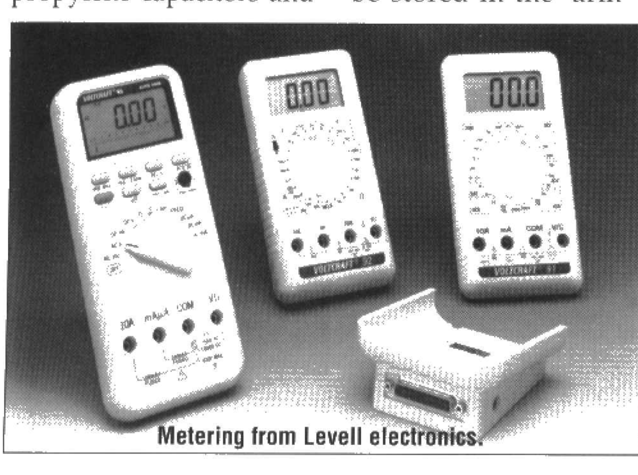
Priced at £399.99 inc VAT, the 310s have a frequency response from 35Hz to 18kHz and can handle 120W peak power. They measure 50 x 24 x 34cm and weight 14kg each. More information can be obtained from CSE Tel. 0423 528 537.

The Dali 310s.

The Borg Arrive

Looking like something out of Star Trek The Next Generation, the latest computer from the US weighs 13 ounces, fits over the hand and forearm, contains a small screen and keypad and emits a red laser beam.

Acumax is actually for use in warehousing and is designed to improve productivity allowing wearers to read bar codes at a distance – they simply point and scan. The information can then be stored in the 'arm' set or transmitted back to a central control for immediate inventory update and control. The laser scanner itself is mounted on the back of the hand and is about the size of a mouse. ■



Metering from Levell electronics.

Not a cyborg but a wristbound computer.

Practical Computing

The latest news from Anthony Robertson

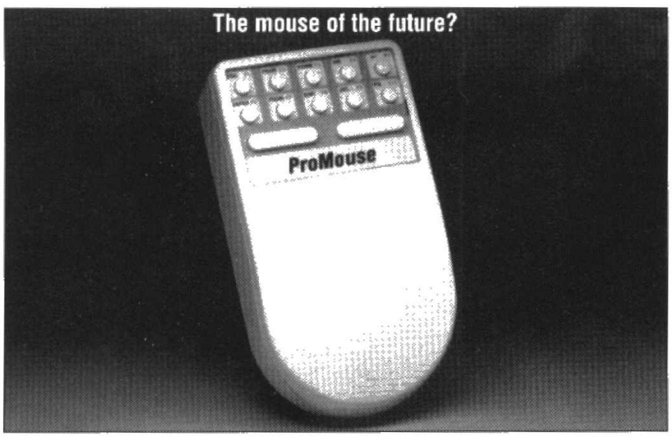
It's not what you do, it's the way that you do it, or so the cliché goes. Unfortunately a number of computer mouse companies have been taking the phrase a little too literally and whilst the computer mouse has undoubtedly improved over the last few years, advances have been restricted to the efficiency in which the mouse carries out it's functions.

Mouse functionality is severely restricted by a lack of buttons. Most mice are limited to two, perhaps three at the most – ideal for clicking, grabbing and moving icons, but little use for anything else. There has not been a product which actually adds to these functions – until now.

The new ProMouse from ProHance seems to provide a solution. In addition to the customary two function buttons, the ProMouse has 10 extra keys. These provide two important benefits. First of all it means that the most commonly used functions, such as Escape or Page Up can be accessed from the mouse.

Secondly, because all these commonly used functions are grouped together, life is made easier especially for people who are not necessarily familiar with all the computer functions.

The ProMouse will retail for £59.99 inc VAT (£51.06 Exclusive of VAT). For more information please contact: SpectraVideo on 081-902-2211.



The mouse of the future?

CD Easy

Hot on the heels of their joint venture with Apple on developing RISC technology for multimedia applications. Acorn in partnership with Cumana, have launched an easy to use CD-ROM system based on the popular Archimedes computer and Cumana CD-ROM drive. Costing just £1,799 (Exclusive of VAT), the system is designed to provide a `plug-in-and-go' solution for first time CD-ROM users.

The system includes an Acorn A5000 computer with 4Mb RAM and a 40Mb hard disk, a colour multiscan monitor, a Cumana CAA 532 CD-ROM drive and SCSI interface, as well as a pair of mains powered stereo speakers. This new product provides a complete


Acorn CD-ROM solution

multimedia presentation system for little more than the cost of a home computer.

A selection of seven CD-ROM discs completes the package Titles include, Revelation 2 – a paint and image processing package and library of colour images, Space Encyclopaedia, The Hutchinson's Encyclopaedia and The Times and The Sunday Times Sampler. Further information can be obtained from: Steve Dickenson at Cumana Limited on 0483 503121.

Computerised Movies

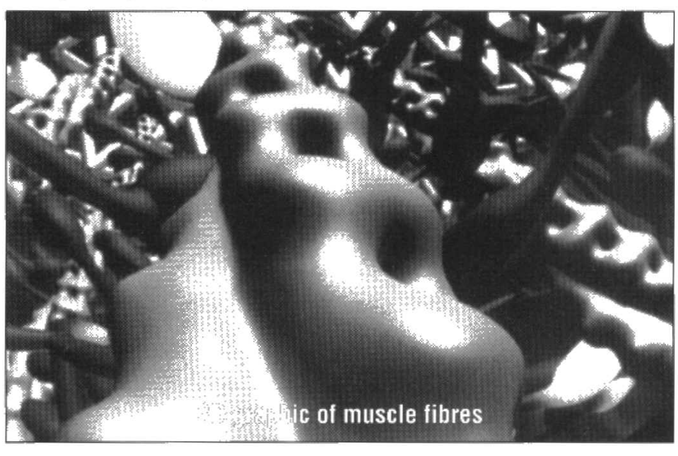
Computers are rapidly replacing cameras in the race to produce blockbuster films. To date films like Terminator Two and Tron have relied heavily on computer generated special effects interspersed with live action footage.

Now Fujitsu have released the first wholly computer generated 3D , wrap around film, entitled "Echoes of the Sun". This 20 minute film costing £17 million, is being screened at Expo 92 in Seville until September.

"Echoes in the Sun" is based on the journey of a particle of light from the sun to its final transformation into human energy. It uses revolutionary technology available through advances in computer aided graphic design. So far the presentation has had a quite literally mesmeric effect on those fortunate enough to view it.

A convincing illusion of three dimensional perspective is achieved with special glasses incorporating LCD lenses which become opaque or transparent, according to the impulses received by an infra-red receiver, with a pulse sequence of up to 96 times per second.

Eventually this technology will be applied to Hollywood productions – judging on public reaction, that time may not be too far off. For more details please contact Andy Crisp at Fujitsu on 081-573-4444. ■


...ic of muscle fibres

CD-I Arrives Five Months Early

Is Compact Disc Interactive the future of home entertainment or just a passing fancy? Will Philips beat Commodore to set the standard? Arthur King answers has the answers.

Five months earlier than anticipated, Philips has started to sell CD-I multimedia players in Europe, starting right here in the UK. The price is £599 including VAT and a voucher towards £50 worth of CD-I discs. Currently there are only 32 titles available but 5-6 additions are expected per month which will probably amount to a selection of around 70 by Christmas. 25 outlets in London are already selling CD-I players in London and a dealership network of 500 outlets is planned in time for the all-important Christmas period.

A demonstration of CD-I full motion video left many at the London launch event feeling that a major breakthrough had been made in digital video on compact disc, though full motion video (FMV) won't be available until the end of this year.

Philips CD205 CD-I player.

The expectation is that FMV will be available as a plug-in hardware upgrade module by the end of the year and Philips says it will be "affordably" priced.

The arrival of CD-I (Compact Disc-Interactive) in Europe follows its US launch almost a year ago at the CES Summer exhibition in Chicago. The US got priority partly because Philips decided to concentrate on the home territory of CD multimedia rivals Commodore with its CDTV system. Philips describes its US launch as 'highly successful' but there are no figures to support this.

There was also an optimistic hope that by autumn 1992, the planned European roll-out date for CD-I in Europe, FMV would be ready. Instead, Philips in the UK decided not to wait for the autumn and so has released the basic specification consumer model 205 CD-I player, which is similar to the version being sold in the States bar television standards differences.

What is CD-I?

CD-I is designed with a huge and sometimes confusing array of abilities. A basic CD-I player, which looks just like a typical HiFi music CD system, can play ordinary music CDs. The Philips 205 model has bitstream digital sound shaping as standard so it should have respectability in a good HiFi set up. However, CD-I is all about visuals.

After hooking your CD-I player up to the TV you can play CD+G (CD with graphics) compact discs. These are normal music CDs with a sub-track which plays back as graphics on the screen – either in the form of crudely animated images or lyrics displayed in time with the music. CD+G titles are slowly gaining popularity, especially with the current interest in Karaoke sing-alongs. Player controls and status are displayed on-screen when selected. The display includes track numbers, forward, reverse, stop, pause and play icons plus a clock/timer and readouts to indicate other functions like shuffle, repeat, CD tray open, and so on. Functions are selectable by moving a pointer with the supplied cordless thumb controller.

An important coup for CD-I was agreement with Kodak to incorporate Photo CD (PE - February) into CD-I's specification. All CD-I players will be able to display high quality photographic images shot on ordinary 35mm film and archived digitally on Kodak's

new CD-based storage medium. The quality is very good too – much better than a still-video frame, for example.

All the features listed so far serve merely as icing on the cake. CD-I combines digital audio and graphics with interactive control, essentially a definition for multimedia. CD-I discs with their 650Mb capacity can be fully illustrated electronic books which you can read, watch and listen to. CD-I lets you halt playback, advance forward or backwards like a tape player, jump to another chapter, stop and answer some questions and jump back to continue with the passage you were originally on, plus a number of other functions. Part screen motion video clips are already incorporated on some of the initial 32 titles available for CD-I.

Undoubtedly CD-I will become a key training and educational tool. One CD-I title, Cartoon Jukebox, illustrates this impressively. The disc is aimed at youngsters and combines a simple paintbox facility with some beautifully animated cartoon characters, almost as though they were lifted from a Hannah Barbera cartoon. The idea is that while the colourless characters are performing a song and moving around the screen you wield a huge paintbrush to a dollop 'paint' on the scene. You can stop the action and colour it in with more care and accuracy, start from scratch, restart or choose another of the fifty cartoons to paint. This particular title was highly impressive and hopefully fully representative of the quality of CD-I titles in general.

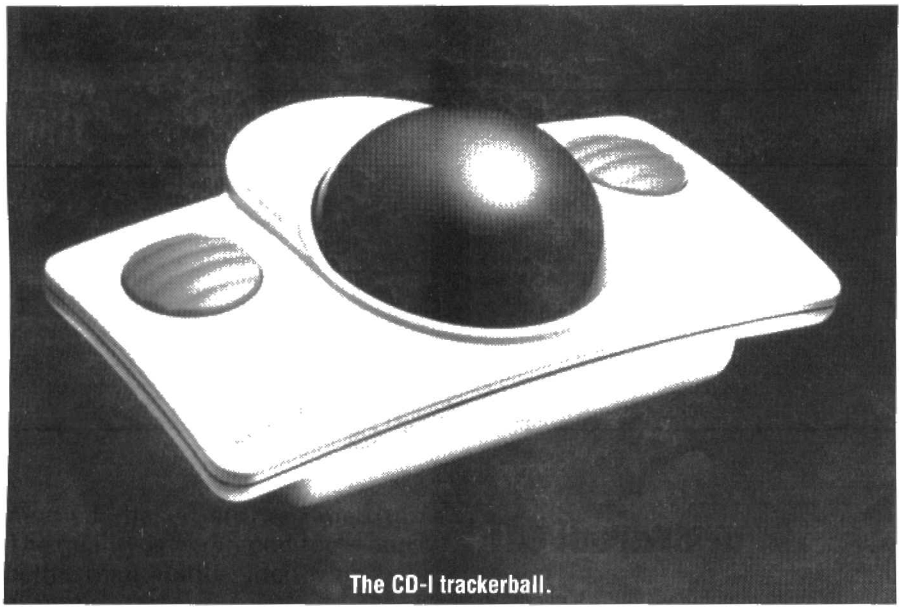
The Hardware

Philips CDI205 technical specs (European model):
Playback:
CD-I, CD digital audio (DA), CD-DA and Graphics (CD+G), Photo CD.
Interfaces:
RF+Channel selector
Pal Video (CVBS) out
SCART (CVBS + RGB)
S-Video
Stereo Audio
Thumbstick control
Pointing device infra red sensor
RS232 serial
Audio digital to analogue conversion: Bitstream sound shaping.
Optional extras:
CD-I Roller Controller: a large trackerball aimed at children CD-I Trackerball: A PC quality desktop trackerball
CD-I Mouse: Futuristic looking PC-style mouse CD-I Joystick
All connect via the serial interface at 1200 baud.

Another interesting CD-I title, Time Life Photography, is an electronic interactive version of the well known books on how to improve your camera toting technique. CD-I lets you 'take' pictures and see the results of under and over exposure, varied lighting conditions, composition and so on. You're not actually using a real camera, but controlling a 'virtual' one via a joystick. Opera fans might like to try Pavarotti: O Sole Mio, a CD-I disc which combines various CD-quality soundtrack performances by the opera maestro with interactively accessible displayed information about the pieces being performed plus trivia and images relating to the great man's life.

After an interactive learning session, time for some leisure. CD-I isn't just a playback system, it has computing ability too and it has the potential to be a mean video game console. How about the old favourite, Battleships? CD-I brings the classic board game into the electronic age with recorded sound effects and part screen motion video clips of real battleships in action. There's also backgammon, Sargon Chess and a new angle on Connect Four. If those are just a little too basic, Pinball begins to show what CD-I is capable of. Well designed graphics, smooth scrolling backgrounds and fast moving animation are combined with realistic sound effects. Nintendo has already been signed up by Philips to provide established console characters like Super Mario, and the rest for future CD-I game releases.

Perhaps the best known leisure title on CD-I is a golf simulation which has been demonstrating CD-I at multimedia shows, conferences and exhibitions for longer than I can remember. This has now been finished into a commercial title called The Palm Springs Open. Animated players are combined with real-life views of courses and opponents. At a glance it's difficult to tell that the scene is semi-artificial. You even get commentators advising you on your swing.



The CD-I trackerball.

Full Motion Video

The consequences for CDTV

The saying goes that Commodore saw its opportunity for a multimedia device similar to CD-I after Philips' continued inability to get CD-I anywhere near a production schedule. Commodore suffered a year long delay itself, but CDTV reached the shops six months ahead of Philips in the US and a year ahead here in the UK. A CDTV player looks remarkably like a CD-I player – both look like a typical front loading stacking HiFi CD player anyway. But the CDTV has Commdore Amiga personal computer internals, hence the short development cycle.

Unfortunately, CDTV's relatively puny custom chips and central processor were never designed to do the specific tasks demanded of a pukka multimedia system. What Commodore has achieved with CDTV is commendable, but software quality has been patchy, there's no way some of CD-I's truly impressive graphics and audio can be matched by CDTV in its present form and there's no Photo CD compatibility or prospect of full screen FMV.

There's not much evidence that CDTV's advantage in getting to market early has established an unassailable lead. Commodore can't compete on quality, but it probably can on price. A CDTV player is £100 cheaper than a CD-I one and that difference could extend to £200 if Commodore drops the price further to £399. To counter that, Philips only has to remind us that big guns like Panasonic and Nintendo are committed to CD-I while both Sony and Sanyo have demonstrated prototype portable CD-I players. Then there's that superb FMV module in the wings and Philips' superior connections in the consumer electronics retail business. It could be Betamax versus VHS all over again, except unlike Betamax, the loser won't be the inferior technology this time.

To be frank, hardened technology journalist acquaintances of mine were heard to be muttering that CD-I does nothing more than was promised. It's polished multimedia and it works very well, but where is the FMV? This aspect of CD-I nearly ran the whole project into the ground a few years back. Full motion video, comparable to VHS video tape, had been promised as far back as 1986. For several years Philips struggled with the technology, indeed giving up at one stage and starting literally from scratch. It's clear that Philips' perseverance, with some hardware assistance from Motorola, has paid off. If the demonstration we were shown is anything to go by, Philips has at last delivered the long promised CD-I capability over 70 minutes full motion video with a stereo sound track. This has been achieved through 100:1 data compression using advanced MPEG coding combined with technology borrowed from DCC (digital compact cassette) for the audio. We were shown a clip from the start of the Bond Movie Licensed to Kill. No doubt this was to show CD-I FMV could cope adequately with all the action showing Timothy Dalton being pursued at high speed around the Rock of Gibraltar by terrorists. The picture looked a little washed out, though that was more than likely to do with the video projector at the screening rather than the CD-I reproduction. There were no noticeable glitches or the characteristic telltale pixel mosaics discernible in other CD-based FMV systems.

The potential for CD-I full motion video is enormous. The medium is slightly too short for full length feature films, but CD-I FMV could spawn a new market in pop videos and TV programme re-releases as well as interactive movies. The technology must have an impact on the older analogue video disc standard which failed here in the UK but is still popular in the US.

To put the two technologies in perspective, CD Video singles are hard pressed to contain more than 15 minutes of action compared with the theoretical maximum of seventy four minutes CD-I FMV.

However, we might not see a rush of FMV releases even after the FMV upgrade module becomes widely available. Apparently this is because currently the coding technique apparently needs a fair amount of expert human intervention at the

Kodak's photo CD is CD-I compatible.

Playing The Generation Game

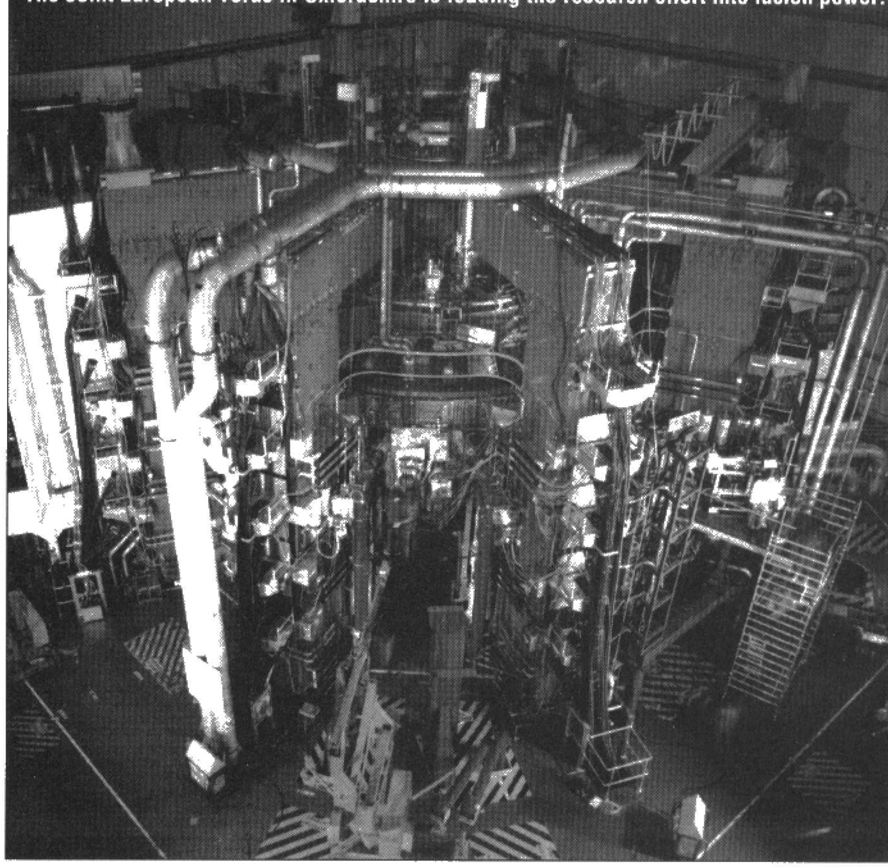
John Brook surveys the current state of the electricity generating industry and takes a look at its future.

We all rely on electricity, it's what makes modern western lifestyles possible. It is used for lighting, from bedside lamps to kilometres of motorway, it powers electric motors in everything from hairdryers to locomotives. It powers all of our communications systems, TV, computers, central heating, cookers, in fact, electricity is probably the most flexible form of power distribution possible. So, where does it all come from?

The Centre Of The Circle

At the heart of almost all electricity generating systems is the star around which our planet revolves, the sun. All power sources used to generate electricity can be traced back to the sun. Fossil fuels such as coal, oil and natural gas are products of photosynthesis and of living organisms that depended on the sun for life. Waterfalls that are tapped for hydro-electricity are a product of the sun's energy impacting on the water that covers 71% of the earth's surface. The water is lifted into the air by evaporation and falls again when the humid air can no longer sustain the load. Tidal barrages use the daily change in water level caused by the sun and moon's gravity on the earth's surface water. Wind is generated by the sun warming certain parts of the earth more than others causing bodies of air to move around which can be tapped by windmills.

Direct sunlight itself can be used in a number of ways to produce electricity. The commonest is the solar cell which utilises the photoelectric effect to generate electric current. Other systems focus sunlight onto pipes containing water to turn it into steam which can be used to turn generators.



The Joint European Torus in Oxfordshire is leading the research effort into fusion power.

The exception is nuclear power. In both of its forms, fusion and fission, it uses fuels which are not directly dependent on the sun. Uranium, the heavy metal used in most atomic plants is formed in the heart of a supernova and the deuterium needed for nuclear fusion is found as a small percentage of hydrogen and is produced as a by-product of stellar fusion.

The Sun

The energy output of the sun is phenomenal. In one year it emits about 5.4×10^{33}J of which only 2.7×10^{24}J hits the earth. Most of this is reflected away by clouds and only 35% is absorbed. The power that reaches the ground is at most 1.2kW/m^2 and on average only 0.8kW/m^2 – to gain some idea of what this means, a one bar electric fire gives out around 1kW.

The surface area of the earth is approximately $5 \times 10^{14}\text{m}^2$ of which about half is illuminated by the sun

Powergen and National Power electricity generating stations in England and Wales.

at any one time giving around $2x10^{14}$kW per year reaching the earth or $2x10^{11}$kW per hour. Whichever way you look at it, this seems like an awful lot of power, or is it. Power companies talk in terms of selling Tera Watt Hours (Tera is 10^{12}) – the total UK market in 1990/91 was approximately 271TWhours and the total consumption of the planet is, well, rather a lot more than this.

Power Sources

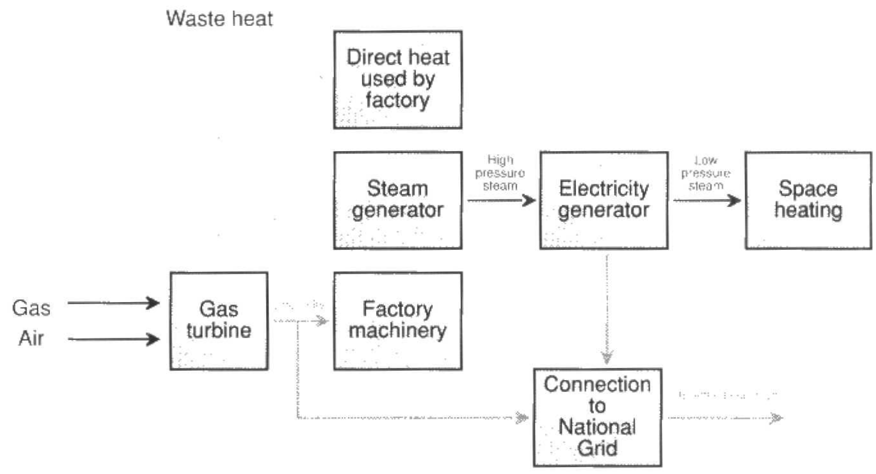
The majority of power generating systems in England and Wales burn coal and are operated by two companies, Powergen with 28% of the market and National Power with 46%. As well as fuel dug out of the ground, a few power stations burn gas and some burn oil. A minority use hydro electricity and there are a couple of wind turbine systems (see map).

In the traditional power station, coal is burned and the heat generated used to turn water into steam. The expansion of water into steam creates a high pressure gas which is forced through turbines whose spinning shafts are connected to electrical generators. These in turn produce alternating current electricity which is transformed up to a very high voltage and connected to the national grid. This power distribution routes electricity to where it is needed in the country. On reaching its destination, the voltage is stepped down to 240V and fed into the home where it can be used.

Alternative heating sources to coal are oil, gas or nuclear. Unfortunately, although all of these are relatively efficient and produce great quantities of heat on demand, each has its drawback and none of them, are particularly friendly to the environment. By far the cheapest heat source is coal but,

Power From Chips

An alternative to the massive National Grid where anyone can extract exactly the amount of power they need, is to generate power just where it is needed. A combined heat and power system (CHP known by its acronym "chip") uses a fuel such as gas to generate electricity, steam and heat. When used in a factory situation, the electricity can be used to drive the machinery, the steam for space heating and the exhaust gases from the turbine generators for drying. The idea is to create a flexible system that fulfils the needs of the customer in an efficient way. A basic system is shown in the accompanying diagram.



Gas and air coming in are burnt in a gas turbine which turns a generator to produce electricity. Excess heat can either be sent up a chimney, used to heat steam for another generator, or used in factory processing. High pressure steam can also be used directly by the factory or, after it has been used to generate electricity, it can be used for heating the buildings. Finally, any spare electricity can be sold off to the National Grid to recoup some of the original gas costs.

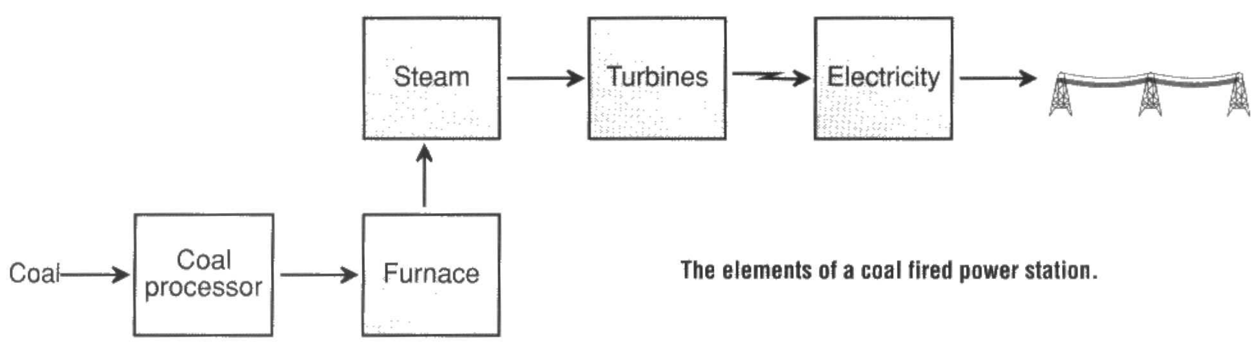
unfortunately, it produces quite a lot of sulphur and oxides of nitrogen as waste which, when they combine with rain water, produce acids capable of damaging trees and polluting lakes and rivers, sometimes hundreds of miles from their source. Most power companies are upgrading their generating systems to filter out the sulphur with flue gas desulpherisation (FGD) and reduce the nitrous oxides with low NOx burners. FGD is able to remove up to 90% of the sulphur which is turned into gypsum (calcium sulphate dihydrate) and sold on to the building trade. Other wastes such as the ash from the spent coal and the warm water left over from the steam generating system can also be sold and used – recycled heat from National Power's Drax station in North Yorkshire is used to help grow around 5000 tonnes of tomatoes and peppers a year.

Making Steam

The latest generation of electricity generating stations will be more efficient than its predecessors. The combined cycle gas turbine (CCGT) uses gas to drive the turbines in much the same way as jet engines. These turbines will produce energy in the usual way via electricity generators but instead of wasting the hot gases from the turbines to the air, they are fed into a steam making system which, in turn, drives its own generators. This gives a fuel efficiency of around 50% compared with between 35% and 38% for conventional coal fired stations.

Probably the most publicised electricity generating system in the UK is nuclear even though it generates a very minor part of electricity used in the country. On the face of it, nuclear power is clean, efficient and relatively cheap, especially when considering that its fuel produces several thousand times the heat than the equivalent weight of coal does. It doesn't pollute the atmosphere with carbon dioxide, sulphur or nitrous oxides and, in some cases, is able to breed its own fuel.

Unfortunately, there are some drawbacks. One of the most obvious is that the fuel is highly radioactive and very dangerous to the environment should it



The elements of a coal fired power station.

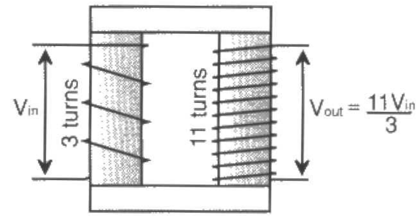
Power Transforming

The reason for using high voltages comes from the fact that the amount of heat generated in a wire by resistance is proportional to the current.

The heat in a wire equals the resistance of the wire times the current in the wire squared times the temperature of the wire or $H=RI^2T$

A way around the problem is to reduce the current in the wire while retaining the same amount of power being transmitted. Since the power in watts is defined as the voltage times the current, increasing the voltage will reduce the current for the same amount of power.

The first power generating systems in the USA, devised by Thomas Edison, used direct current. Unfortunately, electricity generating stations had to be within about a mile of the users as the power losses were so great. The invention of the AC generator and efficient transformers by Nicola Tesla made the modern power industry with its National Grid, practicable.



$$\frac{V_{in}}{V_{out}} = \frac{Turns_{in}}{Turns_{out}}$$

accidentally leak. Because of this, nuclear power plants cost a great deal of money to build as they have to have large number of safety and safety backup systems. During their operational lifetime they become radioactive and since they don't last forever, nuclear plants cost far more to decommission than equivalent coal or gas fired plant, all of which must be taken into account in the running costs. Perhaps the biggest problem is that with names such as Windscale, Sellafield and Chernobyl, the amount of public ill-will directed towards them is tremendous and will probably prevent the installation of any new nuclear stations apart from those that already have planning permission. The nuclear dream may have seemed good at first sight but in the long run it has been very costly.

What may save nuclear power from becoming just another page in history is the development of fusion. Unlike its dirty cousin fission, which requires heavy elements and creates all sorts of long lived radioactive nasties, fusion power uses a deuterium, a fuel plentiful in the oceans. Although it does create radiation, it is generally short lived and so not too dangerous. Unfortunately, fusion power is not yet available and probably won't be for the next 50 years. Although research establishments like the Joint European Taurus (JET) in Oxfordshire have made great strides towards a working system, the money and commitment needed to build a full scale generating station will require the joint input of the major world powers.

Perhaps the cleanest and most environmentally friendly ways of electricity generation are from the wind, the mountains, and, possibly, the waves.

Hydro electricity has been around since the end of the last century. The harnessing of the Niagara falls was an heroic engineering achievement. Since then, a large number of hydro schemes have been set up. Unfortunately, they cannot be used where there is no head of water – some decent hills are required – and it helps if it rains a lot. The other drawback is that, in many cases, dams must be put across rivers flooding large areas of land which could be put to other uses or may be of interest ecologically.

Wind power may also seem like an environmentally correct solution to electricity generation. Unfortunately, the number of wind turbines needed to produce the amount of power created by one conventional power station is quite large. In addition, the wind does not blow all the time and from an environmental point of view, wind farms – large collections of wind turbines – take up large amounts of land and are quite noisy. However, once they are built their power is relatively cheap and the maintenance not particularly difficult.

Another system that may seem like a good idea is wave power, especially since the UK is an island and has quite a windy west coast. Wave power has many of the drawbacks of wind power: a large number of generators are required, they take up quite a lot of space and waves don't occur all of the time – maintenance could also be tricky when the weather is bad.

Other possible systems for generating power are geothermal, where the heat in the earth's mantle is used to turn water into steam, solar power – either direct electrical, or using some sort of focusing system. Unfortunately, these are all very small scale and will probably never be able to cope with the demand.

An Electrical Winter

In the long run it seems that the massive demand for electricity will have to be reduced. Unless a new technology comes along, for example, a working nuclear fusion system, there will come a time when electricity will be both expensive and scarce, especially in the quantities we demand now. Using it to heat a house will soon be thought of as very wasteful and the current profligate outpourings for "luxuries" such as street and road lighting will probably have to stop.

Electricity is such a flexible way of transporting power, it will continue to be used in one way or another. If we are to continue using it at the same rate, the only hope is that a cheap, efficient, environmentally friendly and safe method of production can be found before out fossil fuels finally run out. ■

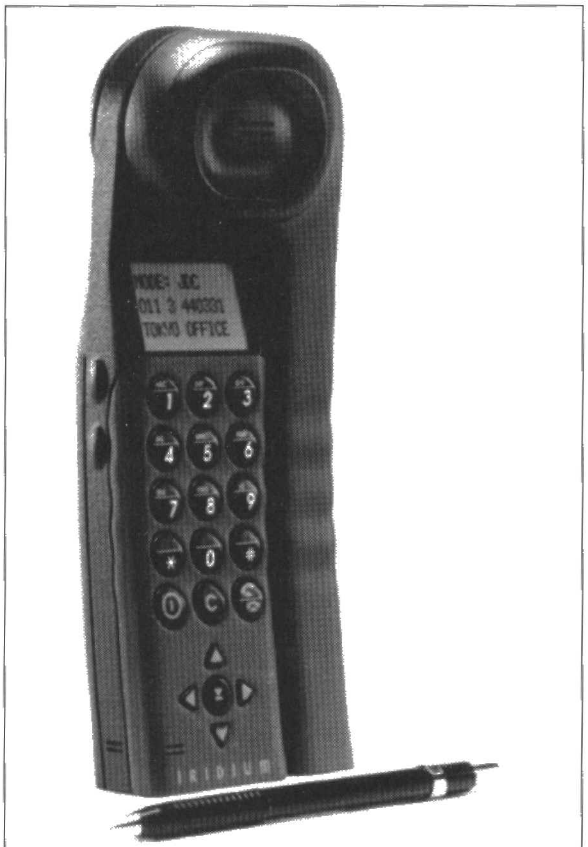
Telephones Into The 21st Century

Comms will be king, one way or another as three new phone systems take their places for the portable stakes. Ian Burley gives the low down.

This month a look at what's on offer just around the corner in the form of advanced personal communications. Plus Psion provides a cellular radio modem for its HC hand held computer, Canon improves its Ion still video camera, PC modems are now credit card sized and do you remember the Keyline project?

What Would Beattie Say?

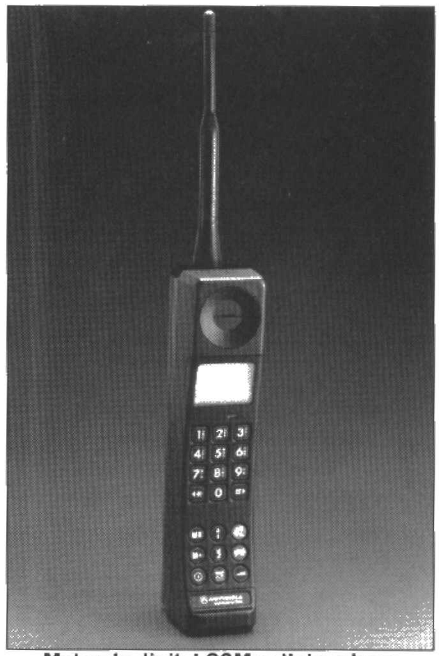
As we rapidly approach the end of the 20th century, could Thomas Edison and Alexander Grahame Bell have ever imagined the rapidly expanding diversity of the technology they pioneered just a hundred years earlier? After decades of gradual refinement, recently culminating in the digital exchange, telephony is poised for rapid development. The race is already on to offer the winning way to carry your voice, as well as pictures, around the world in the not so distant future. The established phone companies no longer enjoy a monopoly in their industry. Cable TV companies are competing to replace the traditional phone line into their customers' homes and even electricity companies are proposing a phone network which will use the mains electricity supply as the transmission medium. It's already possible to buy gadgets which provide phone extensions using the electricity ring main your house.



Motorola Iridium satellite-based global phone

Cellular radio phones, despite comparatively high running costs, have been a huge success – especially in the UK where there are well over a million users. But congestion and cellular's reliance on old fashioned analogue radio communications means the cellphone is a first generation precursor to some far more ambitious mobile personal communications systems.

Already under trial in the UK and soon to be launched nationally is an incompatible but improved cellular phone system known as GSM (Groupe Speciale Mobile). Unlike conventional analogue cellular telephony, GSM uses digitally encoded radio communications between the handset and local base station. Sound quality is better and is not susceptible to distortion when the signal strength weakens. Another important advantage is that more calls can be squeezed into the available band-width.



Motorola digital GSM cellular phone

One headache typical of existing cellular phones is that the special code number which makes the identity of a phone unique to the network, the ESN (electronic serial number), is programmed semi-permanently into the phone. Changing phones means having your supplier to re-program them using a special (and expensive) rig. You can forget about borrowing


Motorola Silverlink CT2 Telepoint.

your mate's phone if you want to get calls to your own number – unless you're happy with the extra expense of call diversion.

With GSM phones the ESN is held in a standard credit card sized smart card. Plug the card into any GSM phone and it becomes your own personal phone. Hire cars will have GSM phones built in, you will be able to hire personal GSM phones at railway stations and airports, or how about receiving calls to directly to your seat on an airliner? Changing or borrowing a hand-set will become an accepted norm. GSM also offers the prospect of fast and error free mobile fax and data communications.

So GSM is the future for personal telephony. Well, not if the backers of PCN (personal communications networks) get their way. The philosophy behind PCN is simple; remove the spaghetti from telephones everywhere through the application of advanced digital radio communications. The optimistic forecast is that early into the 21st century most of us will have a PCN phone in their pocket instead of a land line into the house. It's perfectly logical – why put up with a phone which is glued to your house or office when you can take a PCN phone wherever you go? And that's literally everywhere. The grand plan this side of the Atlantic is for a pan-European PCN network; your PCN phone will go with you on holiday and business trips.

OK, so we'll all be using PCNs and the Star Trek ideal of a pocketable personal communicator will be realised at last. Especially since we might actually be talking to each other via 77 low earth orbit satellites relaying a global mobile phone network. This is the Motorola/Inmarsat Iridium plan, which makes adjectives like 'ambitious' just a little cliched.

The technology on offer is dazzling, but as recent history reminds us, getting commercial services successfully off the ground is not guaranteed. Last month brought the news that Hutchison Telecom had belatedly launched their Rabbit public cordless Telepoint digital phone network. In a blaze of publicity and speculation four operators had been awarded Telepoint licenses two years earlier but all save Hutchison have since withdrawn their services. Admittedly Telepoint's specification, which meant users could only receive incoming calls via a personal base station at home, was considered half baked by critics. However, PCNs, GSM and Iridium are all highly specified and well thought out technologies – and all three are failing to find a sympathetic press.

Panasonic has started advertising its GSM phones, though its ad copy indicates frustration that there is as yet no service for them to operate on. Technical problems, a lack of suitable test equipment and incomplete base station coverage in the country has delayed GSM. It's a similar story with PCNs, with launch schedules being put back as much as two years. PCNs and GSM networks will be competing against each other. The former claim their services will be cheaper and better – naturally this is rejected by the GSM lobby. Meanwhile the Iridium project lurks in the background, struggling to gain credibility.

All this confusion leaves the poor old customer out in the cold. Even when GSM and PCN eventually launch, the customer might welcome the choice, but it will be a very difficult decision.

Psion Goes Mobile

Staying on the subject of mobile communications, Psion has announced a joint venture with


Psion/Motorola portable radio terminal

Panasonic's GSM phone.

Motorola to produce a cellular radio data modem for the HC-series hand held computer, the industrial cousin to Psion's new Series 3 personal pocket computer. Motorola's new RPM405i integrated Radio Packet Modem is incorporated in a neat and compact expansion module for the HC unit. The modem provides real time two way wireless data communication and besides the UK it will work in several European countries as well as the US and Canada. Psion believes there is a large pent up demand for a mobile terminal which can offer instant access to remote databases, both for accessing information as well as delivering locally gathered data.

Motorola claims the RPM405i is the world's smallest and lightest radio designed for data transmission. Users will be able to connect via the Hutchison Mobile and RAM Mobile Data cellular networks in the UK. A Psion HC computer fitted with the Motorola modem is likely to cost about £1500 when the package starts shipping at the end of this summer.

Psion UK: Tel.071 262 5580.

Keyline Into Production

Regular PE readers might just remember my enthusiastic scribblings about the Keyline project over two years ago (PE June 1990). Keyline was devised by ex co-founder of Acorn Computers, Chris Curry. He envisages a simple to use but powerful portable terminal which plugs into the phone and provides the user with teleshopping and access to other services like financial management, booking and even telebetting. The 'power' in the terminal is its ability to accept natural language commands akin to the spoken word. Something like "Order a tin of baked beans and a loaf of brown bread" could be just as easily interpreted by the Keyline terminal's intelligent parser as "I would like one loaf of brown bread and a can of baked beans." Further features like a identification of preferred brands and electronic cash payment via smart cards were also included.

Keyline should have been launched in the Autumn of 1990. Then everything went very quiet. However, nobody declared the project dead and it appears that the small but dedicated Keyline team based in Windsor has not only endured the last two frustrating years, but is now seeing some reward to their patience.

Although a Keyline teleshopping service has not yet been announced, the company has revealed it has secured enough financing to place a £7 million order with London-based Anders Electronics Ltd for the manufacture of the initial batch of terminals in Hong Kong. Keyline spent a great deal of time integrating the electronics of the terminal in order to keep manufacturing costs down to around £50 a unit. This could mean the order is for around 100,000 terminals – certainly no pilot project. Hopefully there will be further news of Keyline's progress later in the year.

Keyline Teleshopping Terminal.

New Still Video Camera

It's ten years since Sony first showed the prototype Mavica still video camera which stored pictures instantly on a compact magnetic disc. Three years ago the first mass-market cameras developed from the Mavica were launched by Sony and Canon. Now Canon has taken the basic Ion camera specification, added a three times autofocus zoom lens and a high resolution option for sharper pictures. The result is the new Canon Ion RC560.

Images are still recorded in

Canon ION RC-560.

analogue form on Mavica-compatible 2in floppy disks. In high resolution mode, twice as much disk capacity is used per picture, so only 25 high resolution images can be stored on a single disk compared to 50 ordinary images. Another new facility provided by a wireless remote control is the ability to display a montage of up to 25 images from the disc all at once. The user can also re-arrange the order of pictures and delete any that are unwanted.

Canon has already produced a package based around the Ion RC560 aimed at Apple Macintosh computer users looking for a portable computer presentation system or a convenient image capture system for desktop publishing.

It's good to see the original Ion's very basic fixed focus/focal length glassware being replaced by a much more useful zoom lens with autofocus. Unfortunately the RC560 doesn't come cheap – expect a price tag of around £2000 for the Apple Mac package when it starts shipping later this year.

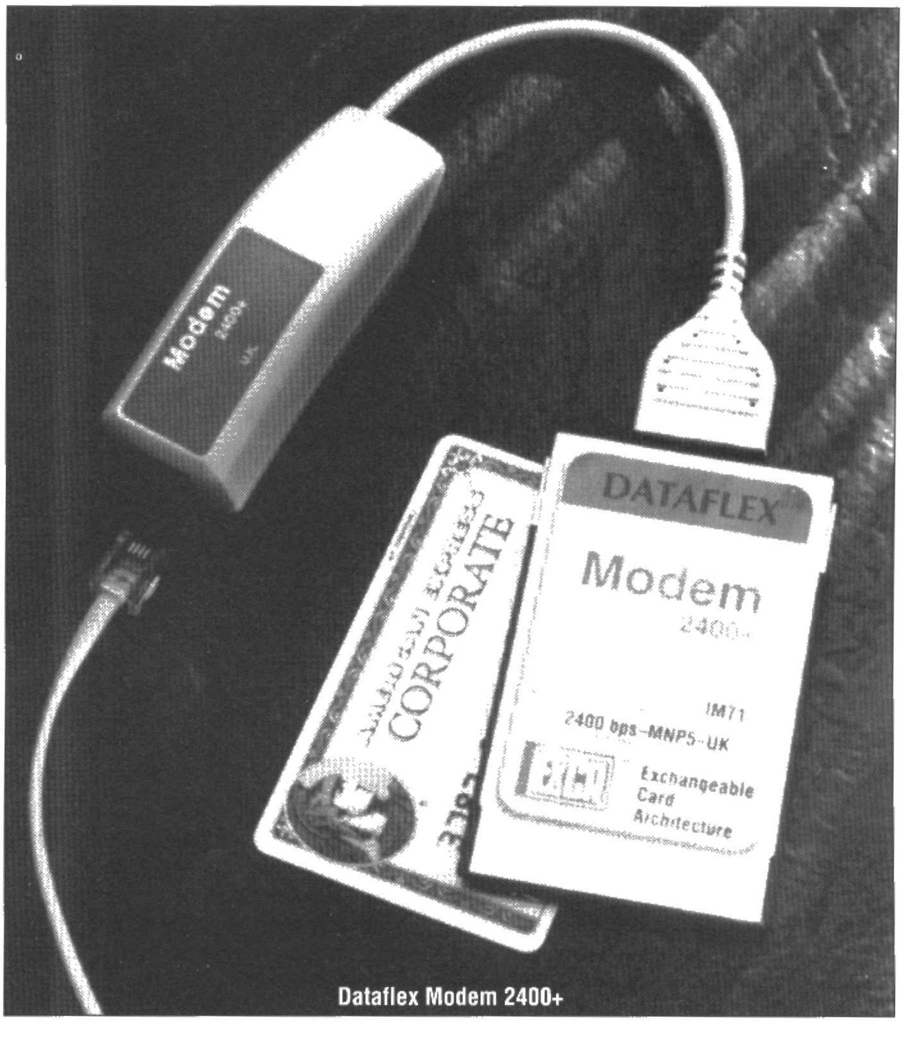
Credit Card Modems

PCMCIA – or Personal Computer Memory Card International Association, the emerging standard for plug-in computer expansion devices no larger than a credit card, has spawned a new generation of diminutive but full-function modems. Wimbledon-based Dataflex Design has already started started selling such a device; the Dataflex Modem 2400+. This is an industry standard (Hayes AT command compatible) modem offering data transmission speeds up to 2400 bits per second (bps), which is V22bis conformant. MNP class 4 data error correction and class 5 compression are incorporated. The modem itself is just 5mm thick. An external Line Adapter Module about the size of disposable cigarette lighter is provided for connection to the PSTN (public switched telephone network).

New computers are increasingly fitted with PCMCIA slots, notably the new Commodore Amiga 600 (see PE June), the Atari/DIP pocket PC and many new notebook and palmtop PCs. External interface boxes for conventional desktop PCs are available to enable PCMCIA cards to be used as well.

Dataflex uses an Intel developed chip-set for its PCMCIA modem, but already the US telecomms giant, AT&T, has announced an even faster chip set which will pack a V32 (9600bps) modem into the same tiny confines of a PCMCIA card. The AT&T modem will also be fax data compatible. Until recently, fast modems like this one often ran quite hot but AT&T has been constrained by power consumption limits imposed by the PCMCIA standard. Power consumption is rated at just 0.8 watts and this slips to 0.015 watts in 'sleep' mode.

Dataflex has priced its PCMCIA modem, including PC communications software, at £399+VAT. For more details call Dataflex on 081 543 6417. ■



Dataflex Modem 2400+

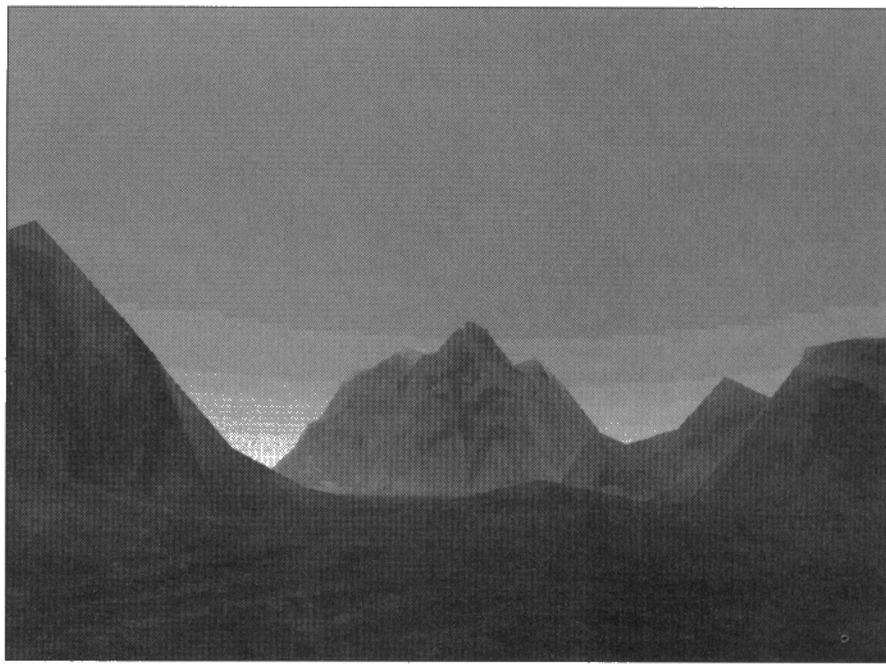
Virtual Reality... Vistapro

Kenn Garroch looks at an impressive program that can create and view three dimensional landscapes, add trees, rivers and even change the seasons.

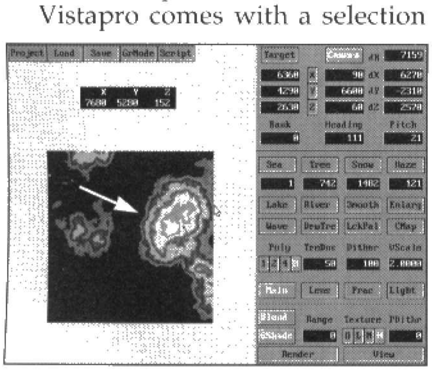
Virtual reality has now become something we all take for granted. The idea that a world can be created inside a computer and then observed by a user is no longer revolutionary.

Most VR these days relies on real-time moving images to get its effect. However, the still pictures and multiple frames of Vistapro are still virtual reality even though they are not real time.

Requiring a reasonable PC with at least a 286 microprocessor, a mouse and VGA, Vistapro is a program for creating landscapes that can be 'walked around'. Once the basic contours have been created, the program can create views from any angle. Camera and target positions can be set either by mouse or by co-ordinates. The render option will then draw the picture as it would appear for an observer behind the camera. This, however, is only the beginning. The user can set the sea level, whether there are lakes or rivers, the tree line and tree type, the snow line and the amount of haze. The colours can be edited so that different times of day and year can be simulated from sunset to autumn. Even the colours as seen from another planet.



Vistapro comes with a selection of scenes to look at, one of which is the Olympus Mons crater on mars. The colour scheme for this is appropriately red. However, by loading in another colour set, defining a sea level, some trees and snow, mars can be brought to life, literally. Once the built-in scenes have been viewed from every angle, a fractal generator allows new landscapes to be formed, zoomed into, stretched and transformed. The example shown at the top uses the set-up screen at the bottom. Everything is mouse controlled and although there are a few quirks, it is quick and easy to use.



One major drawback of the program is that for enhanced graphics modes – mainly super VGA (1024x768 pixels in 256 colours) – a special VESA screen driver is required. The program notes say that these can be obtained from almost any bulletin board system. Admittedly, the various SVGA boards require different VESA drivers. However, after hunting around on CIX I found a file that had every driver imaginable. Why couldn't Vistapro come with this on the disk?

Video modes supported range from low 320x200 to 1024x768 (with the appropriate hardware). A special animate mode allows screens to be saved in sequence and a flyaround simulated with a separate viewer program.

Vistapro can create some stunning graphics and is available for both the Commodore Amiga and IBM PC. However, on a PC, getting the most out of the program requires a 386 or better, otherwise it's a bit of a good-time-to-make-a-cup-of-tea type of program.

Vistapro is available from all good software suppliers. ■

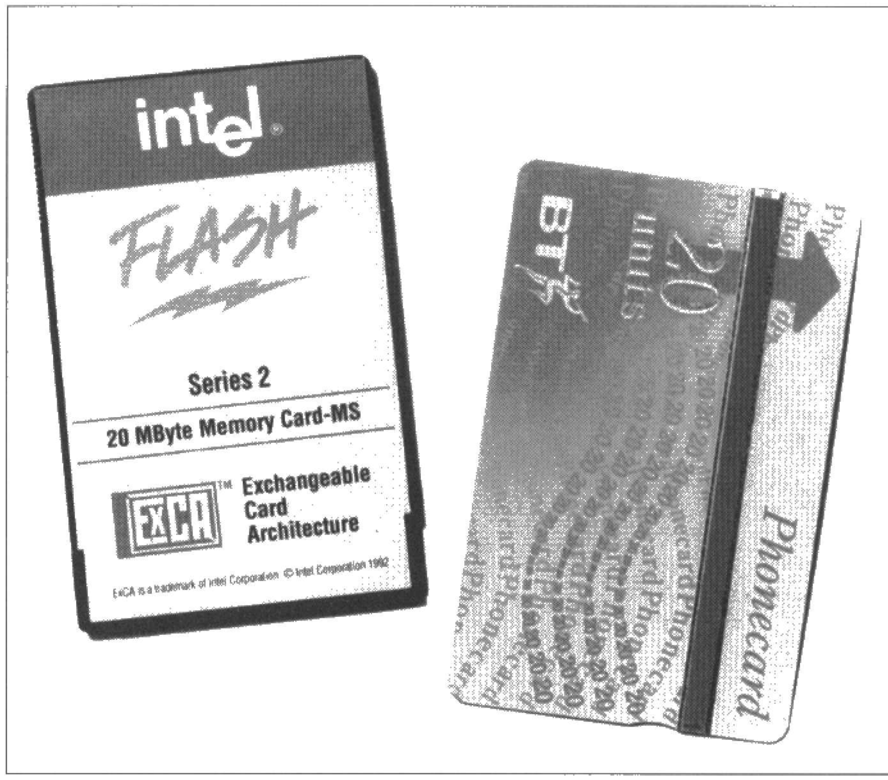
Replacing Memory In a Flash

Is it the end of mass storage as we know it. Is the hard disk about to crash its last? Alan Howe looks inside the latest credit card storage systems to find out.

The age of the floppy disk and perhaps even of magnetic media in general is drawing to a close. The development of flash memory with its solid-state, small size, high speed and high density capabilities looks as though it will become the perfect replacement.

Three big names have recently announced Flash Memory products, AT&T, Advanced Micro Devices (AMD) and Intel. Each has its own technologies but all add-up to the same basic idea: a credit card sized storage system that is completely solid-state, holds up to 40Mbytes of data and adhears to a standard interface alowing it to be used with a range of computer systems.

In addition to the hardware, Microsoft, a leading software company has designed a special filing system and converted its (in)famous PC operating system, MS-DOS, to run from flash memory cards as though they were hard or floppy disks.



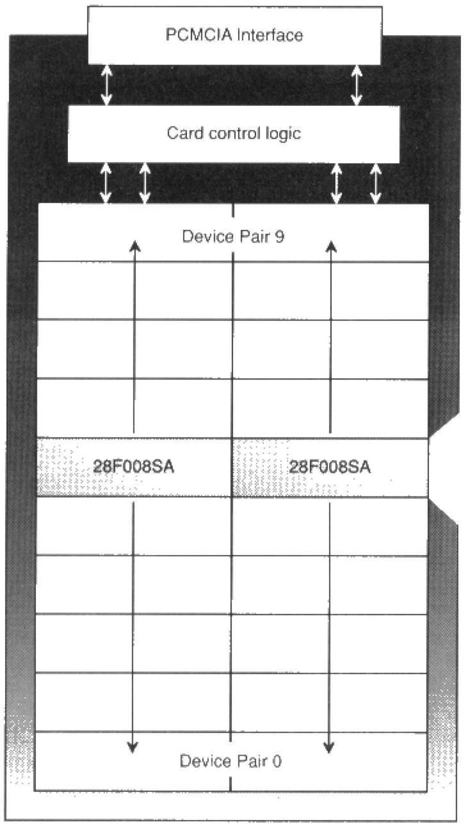
The Background

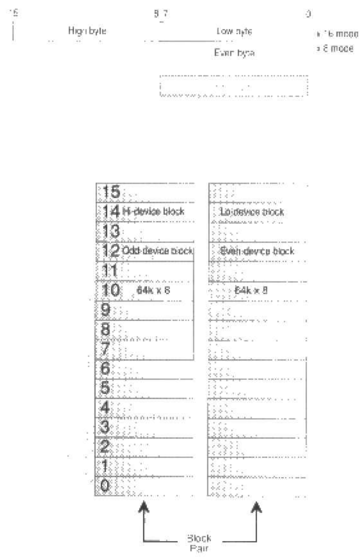
Modern computer storage comes in four main types, RAM (Read And write Memory), ROM (Read Only Memory), random access magnetic media such as floppy and hard disk drives, and serial access magnetic media such as tape streamers. For bulk storage, the disks and tapes currently offer the best value for money with the average floppy disk holding around 800kbyte for a cost of around £1 or less. Hard disks come to about £2 or less per megabyte (a 40Mb removable hard disk costs about £80) and tape streamers are cheaper still but access is quite slow.

For solid state memory, RAM is still very expansive with an 8Mb memory expansion for a 486PC costing about £850 or around £100 per megabyte. At this level, it would be very expensive to duplicate a 100Mb hard disk in chip form. The other drawback is that RAM is volatile – its contents are lost when the power is removed.

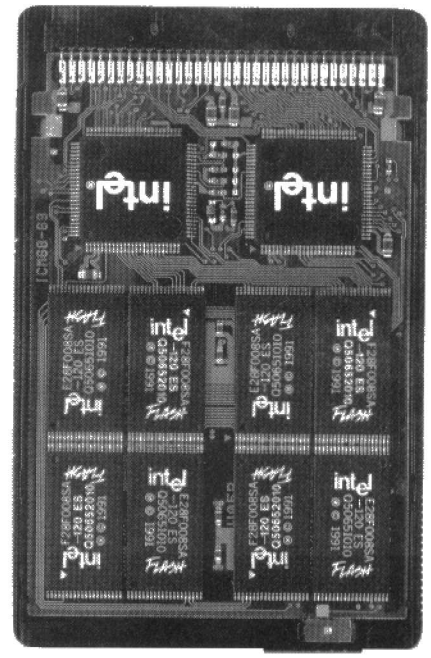
An alternative solid-state memory system widely used in Psion Organiser pocket computers is EPROM – Erasable Programmable Read Only Memory. This can be written in much the same way as a computer memory but retains its data when the power is removed. Unfortunately, to change information that has been written, the whole chip must be erased by exposing it to ultra-violet light for an hour or so. A more modern development is the EEPROM or electrically erasable PROM. This can be written and read in the same way as EPROM but erasing is by means of special high voltage pulses of electricity which means it can be written and erased while remaining connected to the computer.

Flash memory uses similar technology to the EEPROM. However, instead of reading and writing the whole chip in one go, flash memory chips are split up into blocks, each of which can be written or erased separately from the rest. The advantage of this is that altering data is just a matter of reading the contents of the block





The contents of a flash memory card.



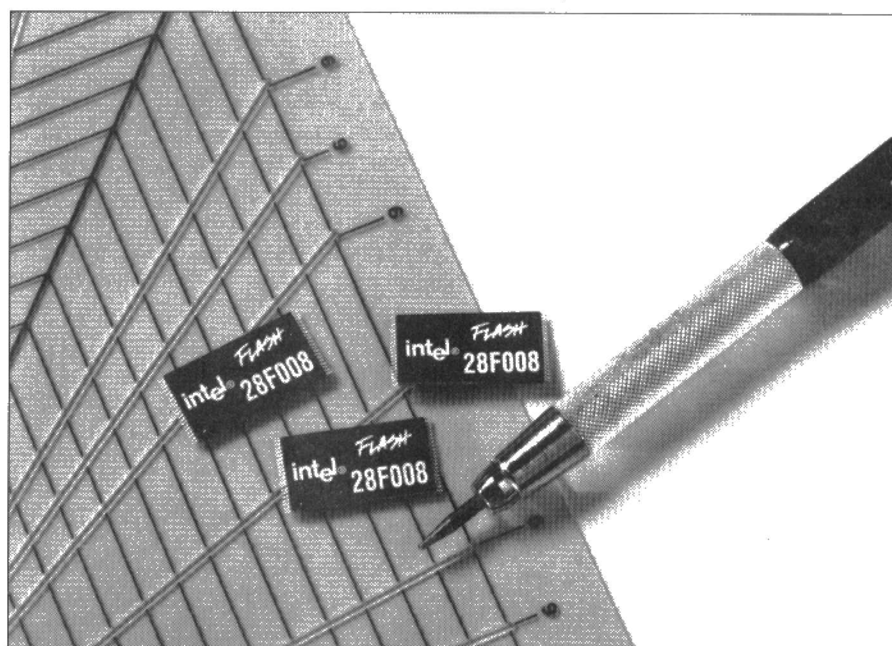
into the main computer RAM – the smaller the block, the easier this is – and then erasing the block on the chip. Alterations are then made to the read data and the modified block written back to the flash memory. In practice, things are a little more complicated than this since each cell or block has only a life of 100,000 cycles. If one block were re-written repeatedly, it would wear out before the others and reduce the possible life of the chip. To get around this, special software attempts to spread the writes around the available blocks to extend their overall operational life.

The Competition

Of the three manufacturers currently making flash memory chips, Intel and AT&T seem to be ahead in terms of actually producing memory cards. AMD seem, so far, to have produced only the chips. However, it is the capabilities of the chips that are most important, especially such things as power consumption, supply voltages, access times and the number of erase/program cycles. All three perform in roughly the same way with the Intel consuming the least power but offering relatively slow access times. On the other hand, the Intel chips hold more data but in larger blocks. Table 1 shows a comparison between the AMD and Intel chips. Data on the AT&T system was only available for complete cards. These come in 2.5Mbyte, 5Mbyte, 10Mbyte and 20Mbyte sizes costing US$425, US$750, $1400 and US$2750 respectively – an average of US$150 per megabyte. Intel's prices are US$163 for 4Mbyte, US$331 for 10Mbyte and US$611 for 20Mbyte although this is for bulk orders only. Intel expects its prices to converge with hard disk costs by 1996 and steadily undercut them from then on.

Flash File System

To get flash memory into the market place requires more than a push from the manufacturers. The technology has to be made to work in real situations an on real equipment. To this end, Microsoft has devised a special filing system that optimises the use of the memory cards.



Operation of the Intel cell

The Intel 28F008SA is made up from 16 equal 64kbyte blocks to make up a total of 8,338,608 bits of memory or 1Mbyte. Each block has 512 columns by 1024 rows. Each of the columns is further divided into eight inputs/outputs, each of 64 columns.

To write data to a byte, the column address determines which eight bit-lines are connected to the programming voltage ($V_{PP}/2$). Row decoding sets the word line to V_{PP}. All other wordlines in the array are set to ground.

Initially, erased cells are set to "1" so writing data to them simply sets any zeros, the ones are left alone. To change the state of a cell from "1" to "0" a technique called hot electron injection is used. Fig a shows the state of the cell when programming is taking place. The wordline or gate is connected to the programming voltage (V_{PP}). The drain or bitline then sees an intermediate voltage level of about VPP/2 and the source is set to ground. The voltage level on the gate causes a voltage to appear on the floating gate which is isolated by a non-conductor. This raised voltage causes an inversion in the channel underneath. The electrons in the channel now have a higher drift velocity and hence more energy. Collisions that occur between these electrons and the substrate atoms heat up the silicon lattice. As the programming voltage reaches its peak, the electrons have more energy that they can get rid of to the surrounding atoms and begin to move faster and become hotter. The energetic electrons eventually start to tunnel through the oxide barrier and accumulate on the floating gate – tunneling is a quantum effect that occurs when the probability of the electron's position becomes large enough to encompass the width of an insulator allowing it to pass through.

The extra electrons stored in the floating gate raise the turn on voltage threshold of the cell. During device read operations this transistor remains in the off state. A "0" results at the output because the "off" cell does not pass current, causing the bitline to electrically stay at pull-up to the V_{CC} read voltage.

To write new information, a complete block must be erased. This process is a matter of routing V_{PP} to the source, ground to the select gate and leaving the drain floating (Fig. b).

While in this state, electrons tunnel off the floating gate reducing the turn-on voltage threshold. During a read operation, the "1" at the output corresponds to an "on" cell discharging its bitline through the grounded source.

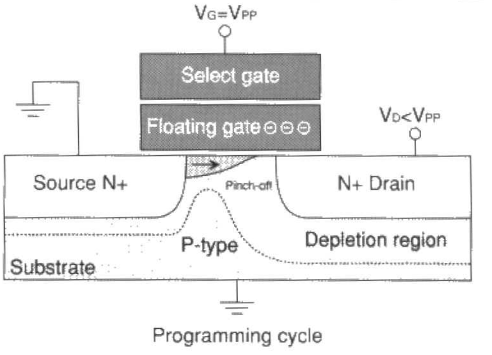


Fig. a

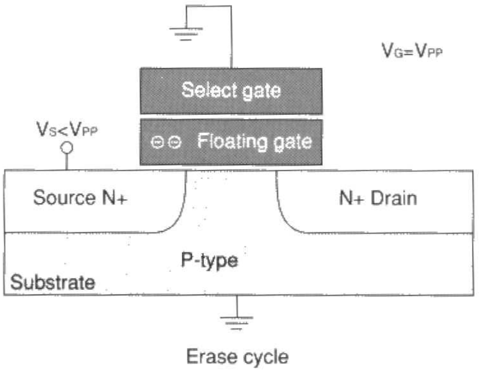


Fig. b

Flash memory will appear to have a similar format to existing disks with tracks and sectors. The actual format of the card will be invisible to the user allowing it to be used with popular filing systems such as Windows and MS-DOS. The file system consists of two device drivers that go into the CONFIG.SYS file. One interfaces with MS-DOS to process commands from the operating system or application and the other does the dirty work of handling the card interface functions. This approach allows different card systems, say AT&T's, Intel's or a system developed from AMD's chips to have different low level drivers but appear the same to the high level system.

A comparison of AMD and Intel

Parameter	AMD	Intel
Power consumption sleep	50µA	0.2µA
Power consumption read	30mA	90µA
Power consumption write	50mA	10mA
Power consumption erase	50mA	10mA
Supply voltage	5V	5V
Access time read	45ns (min)	85ns (min)
Access time write	45ns (min)	85ns (min)
Erase time	1s	0.3s
Max cycles per block	100k	100k
Blocks per chip	8	16
Block size	16k	64k

Data about the AT&T system was unavailable at the time of writing.

Who Will Buy

The trend in electronics is for ever smaller equipment offering ever increasing power. Flash memory cards will offer a good replacement to the conventional hard disk system used in portable computers. By reducing the main storage, the whole size of the machine can be brought down. The current limitations on this lie with the screen and keyboard and developments in voice recognition coupled with ever more powerful microprocessors should eventually see the development of a credit card sized computer with the capabilities of a Cray. ■

Making Sense Of Microwaves

The new European Microwave Signature Laboratory has been set up to help make sense of the flood of information being beamed at us from orbit as Francis Anderson explains.

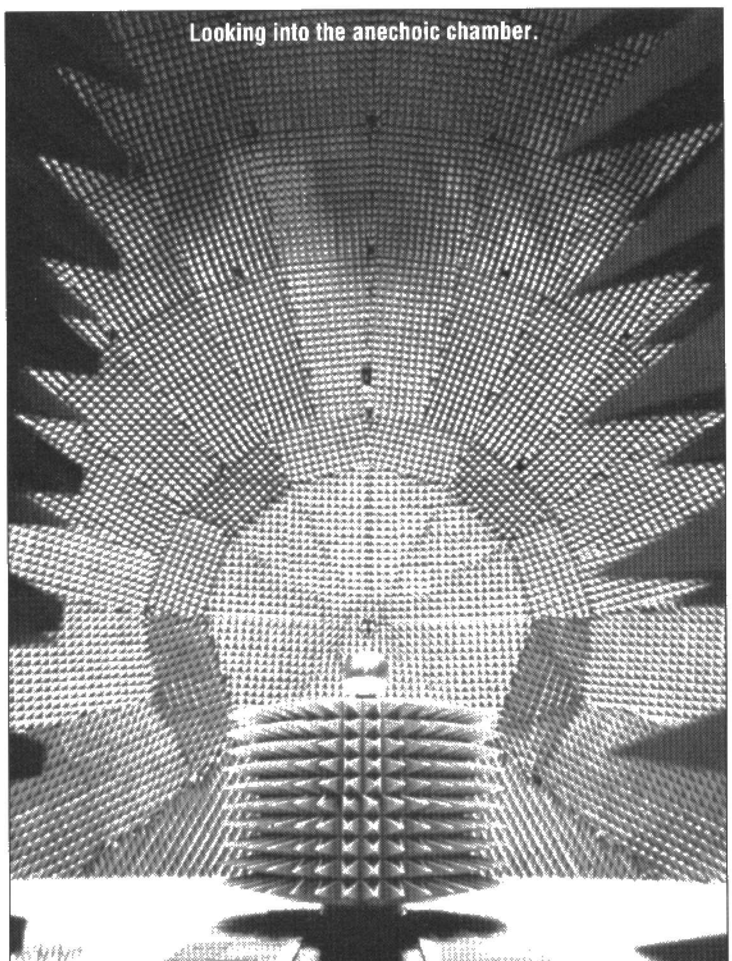
In orbit around the earth are a number of satellites many of which are monitoring the state of the planet.

Unfortunately, the changing cloud patterns make viewing in the visible spectrum quite difficult at times and alternative means of vision have to be sought.

The human eye and brain interprets the colours and textures of the world in a way that is accepted by the majority of people. Looking at things in other frequency ranges is a different matter entirely.

Taking pictures from space in visible light produces pictures that make sense after a little study – trees remain green and many mountain tops are white. Using microwaves to study the earth has the great advantage of being able to see through clouds. Problems arise when attempting to give meaning to the different frequencies received by the satellite as they are reflected or transmitted.

To solve this problem and to help with the vast increase in available data from satellites such as ERS1 (Earth Remote Sensing satellite 1), the European Commission has set up a research establishment called the European Microwave Signature Laboratory (EMSL).


Looking into the anechoic chamber.

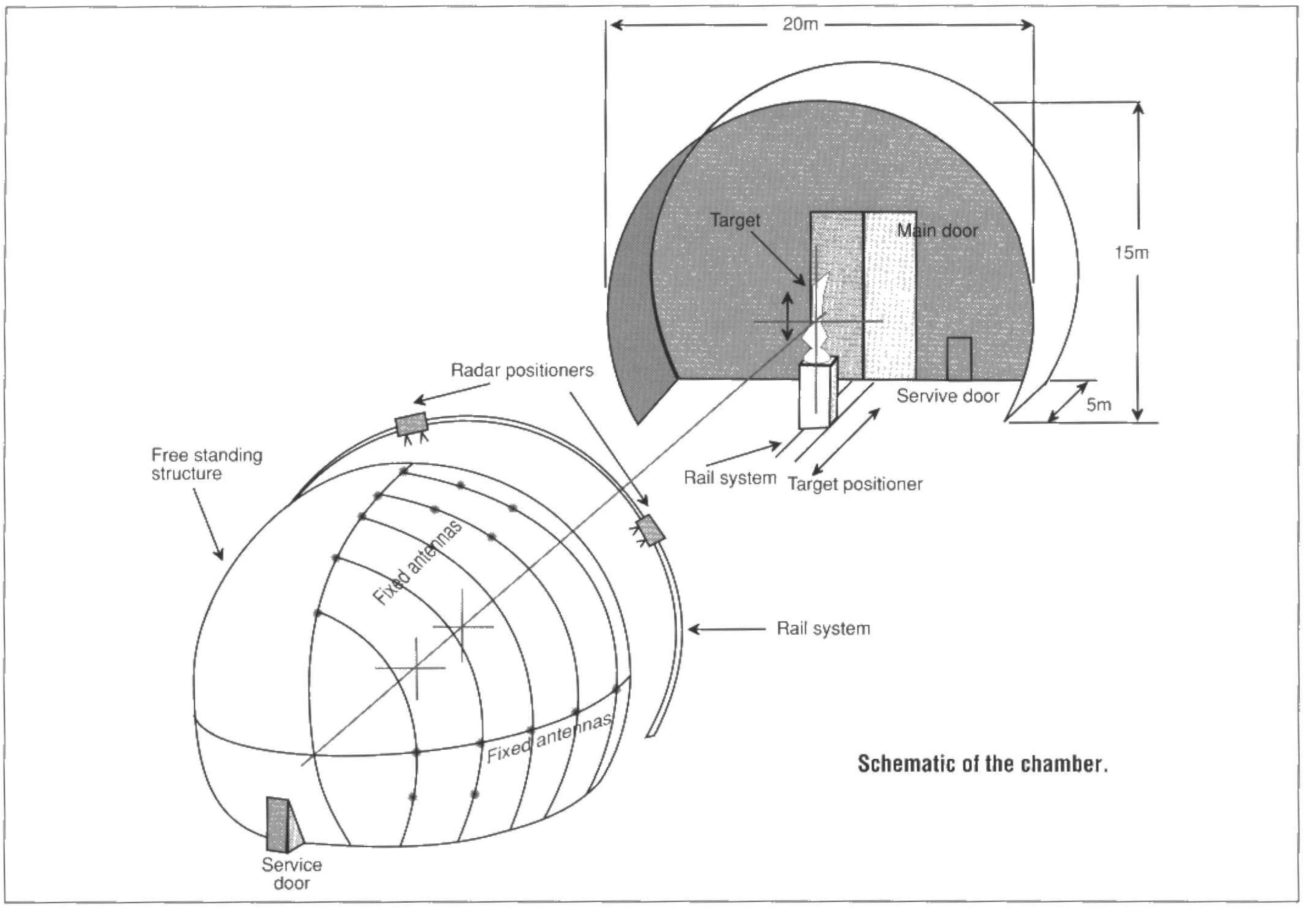
Keeping Quiet

As a microwave anechoic chamber the EMSL allows objects to have microwaves beamed at them as though from an orbiting satellite. The reflections and the way in which the radiation is absorbed can then be monitored, again as though from a satellite, to give a model which can be used to interpret real satellite data.

The test chamber is large enough to accommodate real natural targets such as trees and is able to simulate not only satellite scanning but also the airborne sensors used in airplanes. To provide back-up to the microwave antennae, a large computer system made up from a network of workstations can be used to monitor results in real time.

The overall shape of the anechoic chamber is made up from a hemispherical dome and a cylinder, both with a radius of 10m. The floor of the chamber is at a level of 5m below the centre of the sphere. Along the gap between the two parts a circular arch is mounted supporting a rail system where two sleds can move independently. Each carries a transmit/receive module pointing at the centre of the arch which a target is placed at the focal point. The target is also mounted on rails and can be moved, rotated, raised and lowered to allow any position to be obtained. The rail system extends through the large doors so that objects under study can be set up outside the chamber and then wheeled in as necessary.

In addition to the antennae mounted on the sleds, 80 receive only antennae are distributed over one half of the dome surface. Illumination suitable for living



Schematic of the chamber.

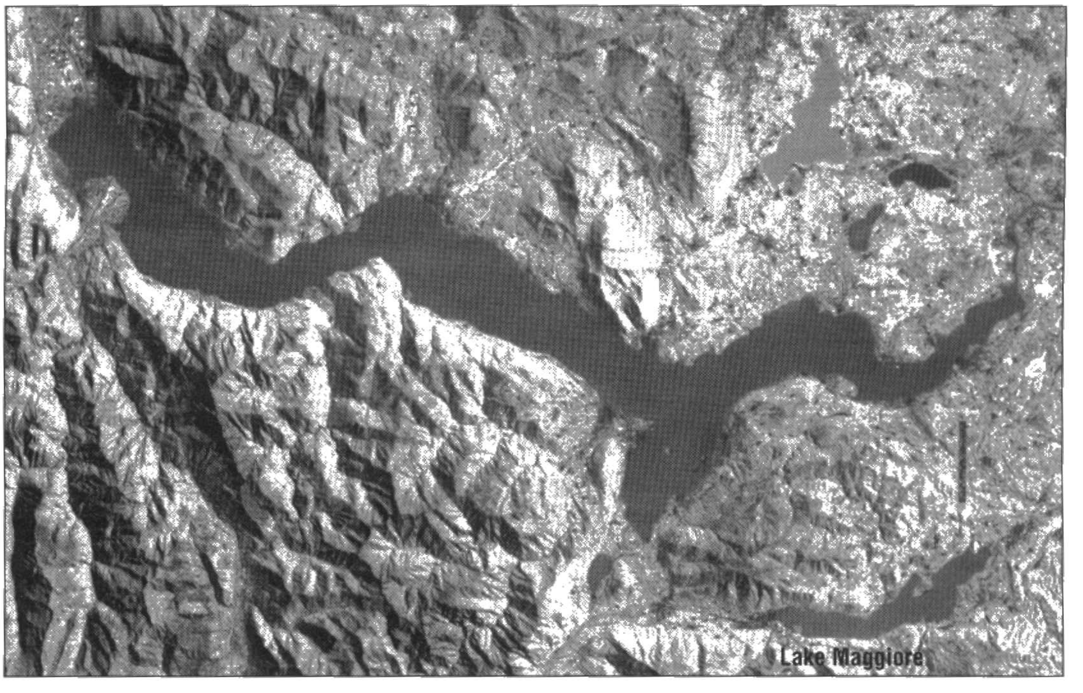
plants is guaranteed by a set of lamps mounted in a recessed portion on top of the cylindrical portion. This lighting can be varied to simulate day and night and climate control allows almost any weather condition to be set up.

Getting The Picture

Using the information gained from EMSL, a detailed image of the earth can be built up that reveals not only large scale structures such as forests and mountains but also roughness of the terrain and its water content – microwaves are strongly affected by the conductivity of objects from which they are reflected and refracted.

Although the pictures obtained by microwave are not as detailed as optical ones – at present, civilian optical satellites can resolve objects down to 10cmx10cm and military satellites are reputed to be able to read car number plates – a microwave radar system such as that used on ERS-1 is able to give about 30mx30m to each pixel of the final image.

Other uses for the laboratory are in the areas of air traffic control and robotics. For example, when designing a new airport, the effects of the surrounding terrain, buildings and industry can have a large effect on the microwave landing radar. EMSL can be used to model the area and see exactly what these effects will be. It can also be used to design new sensors that will tell if an object is wet or dry or new materials that absorb or reflect radar waves in special ways. ■



Lake Maggiore

How It Works... A Dimmer Switch

Derek Gooding levers his way into another household electrical gadget to find out what makes it tick.

There's not much to understand about a light dimmer switch, just that it's a simple but safe means of rapidly disconnecting the lamp from the mains giving control of the brightness to anyone. On the right, the top illustration is of a dimmer control from the early 1970's.

Electronic control of lighting circuits is now so popular that the early problems have been long forgotten. In the past, rotary transformers had been used in some homes to reduce the voltage being supplied to the bulb, theatres replaced the 'toast rack' systems of large variable resistance units that got very hot with the 'Variac' rotary transformer and some used very early electronic switching devices.

In principle, electronic dimmers are just very fast acting switches that pulse electricity to the lamp. Because of the 'momentum' of the filament in the bulb, rapid changes in brightness are smoothed out and the overall effect is of a dimmer light. Unfortunately, very high speed pulsing creates sparking which is the basis for radio transmission and thus dimmer switches can cause a great deal of interference if they are not properly shielded.

On And Off

Our home electricity supply oscillates at a rate of fifty times a second (50 hertz) between a negative voltage and a positive voltage. The simple dimmer switch uses a variable resistor (with ON/OFF switch control), connected to a thyristor (electronic switch) in series with the lamp circuit and controls the length of time the lamp receives full power in each cycle of the 50 Hertz mains supply – the 'high speed' switching. A coil, in series with the mains supply, reduces radio frequency transmissions and 'chokes' mains borne interference. This stops it from travelling around the house wiring to interfere with other sensitive electronic equipment. To protect the immediate environment of the switch, modern plastics materials and a metal cover plate stop the radio interference from escaping from the wall unit itself.

New Ideas

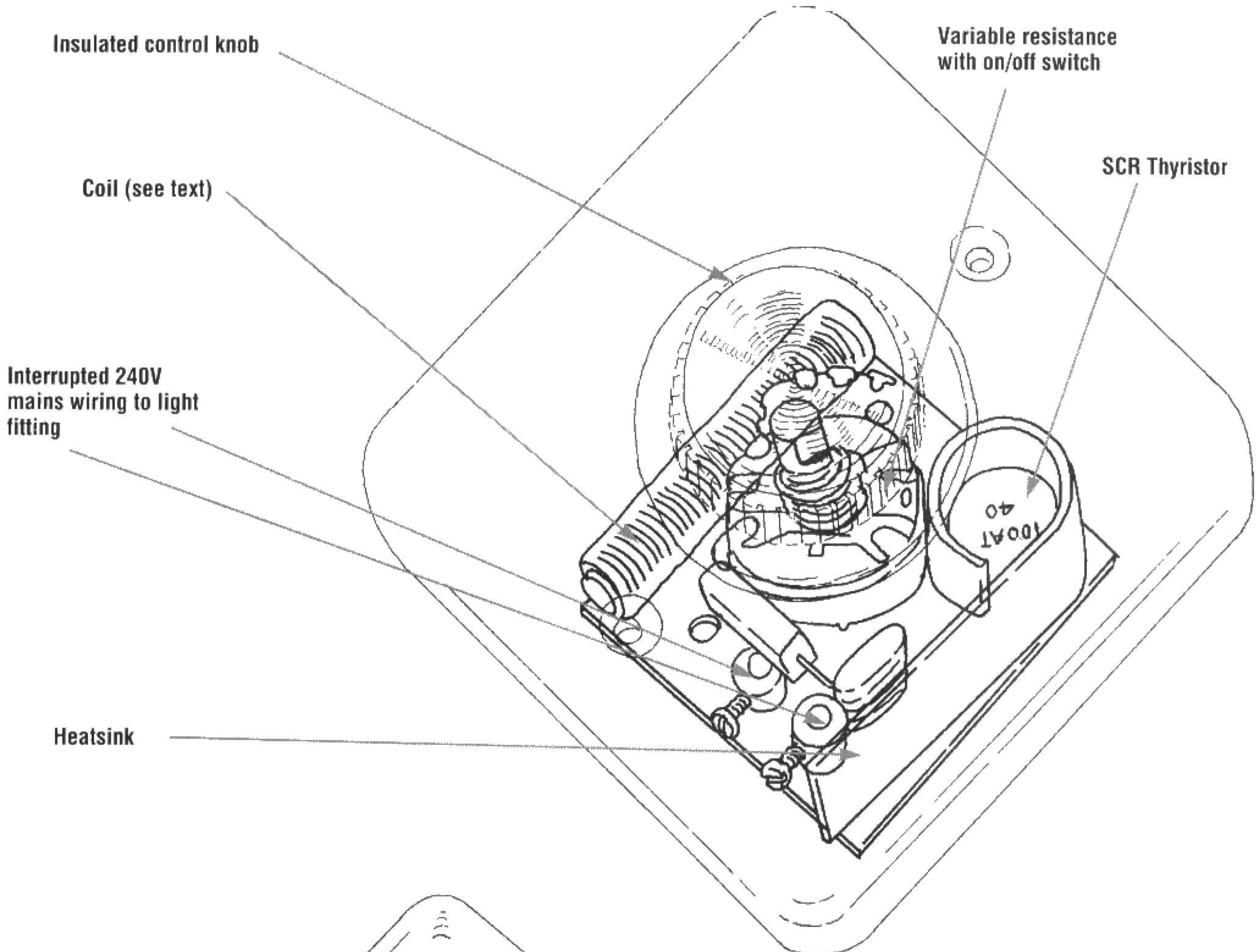
Some years ago it became possible to control lighting levels using a hand held infra red light beam unit. This was pointed towards an ordinary looking light switch with a small infrared receiver either alongside the switch (and battery powered), or occasionally fitted inside the switch. Unfortunately, the problems of suitable power supplies for the infra red unit never really resolved themselves and the system never really took off.

Manufacturers, governments, and euro-technologists are now seeking agreement upon a common standard for future developments of Home Electronic Systems (HES) to define standards for the automated home of the next century. At present we use infrared controls for our video recorders and TVs, and some of us have suffered from the discovery that our 'cheapish' car alarm remote controls can actually switch the channel selection of some VCRs. Even controllers from the same manufacturer only work with some of their models, so we still have some way to go before the family are hunting the mislaid 'master controller' to enable the lighting levels to be changed, the washing machine programmed, the property alarm 'silenced' and the central heating reset. Not to mention the cooking arrangements organised!

The simple light switch will still exist, but I expect it to be a low voltage device capable of detection of movement, sending an electronic coded message to the home's central HES computer via the FIELDBUS, BATIBUS, EIBUS or whatever Euro-standard is agreed upon. The system will sense natural lighting levels and bring 'background' light levels up to compensate and if movement transfers from one area to another the lighting will change to provide a safe level of illumination wherever we go. Great if you go to sleep, the lights go off and when you awake and move, the lights gently come back up to a safe level to smooth our waking moments.

Some Caveats

In the meantime, just remember that most dimmer switches need a minimum load of 60W. Lower values often create an irritating flicker. Too high a wattage can overheat the dimmer controller with the possibility of a fire. Also, beware of the modern low current 'energy saver' lamps as these must not be connected to ordinary dimmers. Special fluorescent dimmer controls need to be used with fluorescent tube fittings but that's another *How It Works*. ■



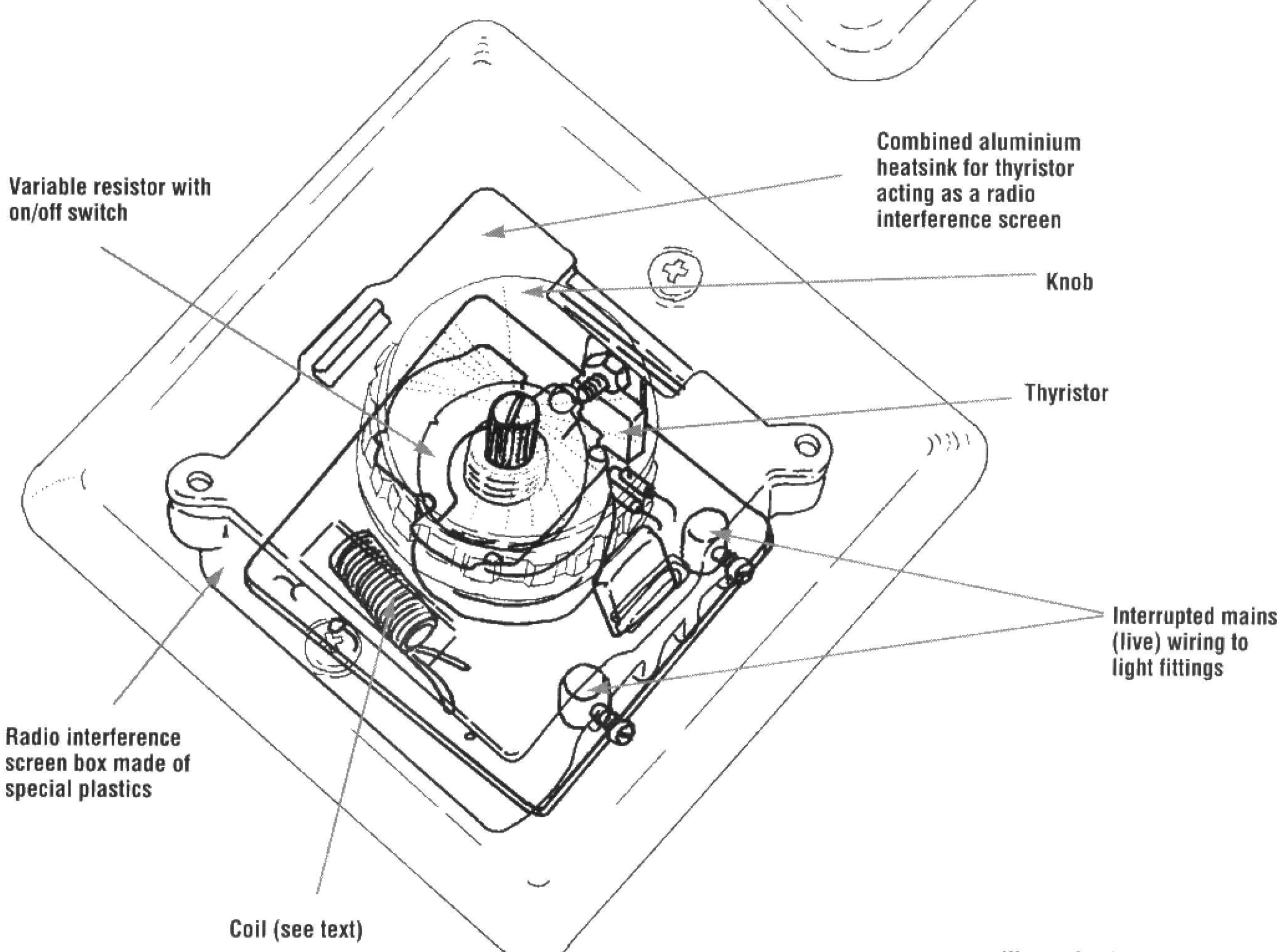


Illustration by Derek Gooding

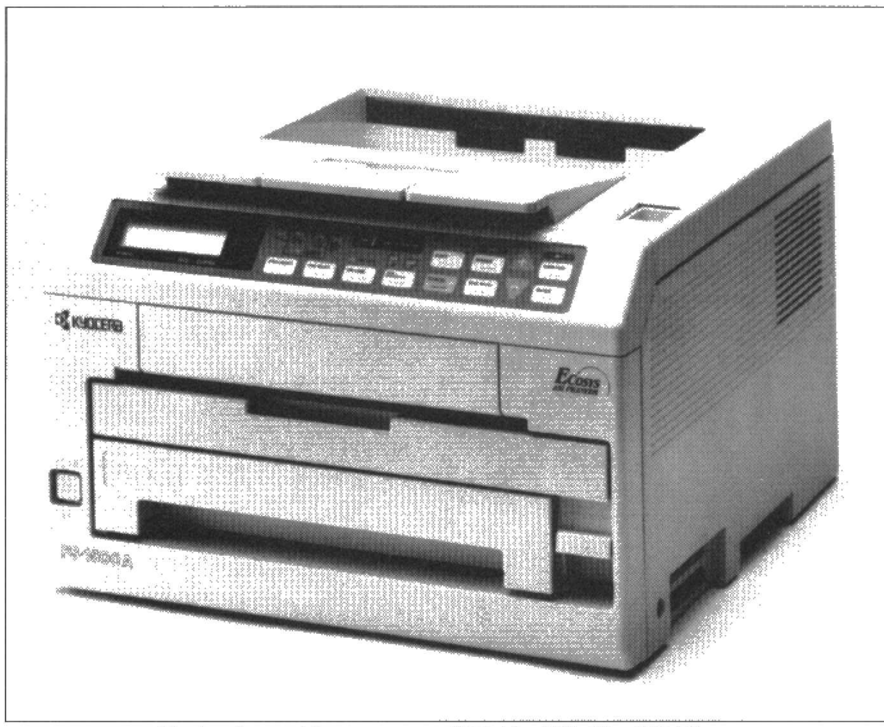
Product Preview... Kyocera Ecosys

Claiming to be environmentally friendly, the FS-1500A uses a variety of new technologies to reduce costs and improve quality.

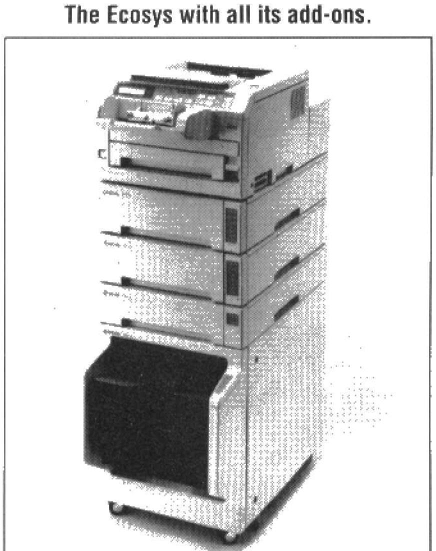
For the past few years, the industry standard for computer printers has been the laser cartridge system. Almost every office that is "computerised" has one of these beasts in the corner and anyone who has used one will know of its voracious appetite for toner cartridges. All improvements in printing technology have simply been upgrades of this now standard system until now.

With the introduction of its FS-1500A and eco friendly features and LED (light emitting diode) scanning system, Kyocera looks as though it has broken new ground. Gone are the days of having to replace the print drum as the amorphous silicon (aSi) drum used in the 1500A is expected to last the life of the machine or some 75 times the life of a standard laser system.

At the heart of the new system is the long life aSi drum/ developer /fuser/LED imaging system. This is able to produce 300dpi images – the same as a laser printer – for one quarter of the cost. To help keep the drum clean, a new toner has been formulated based on ceramic technology. This polishes and reconditions the drum every time it is used.



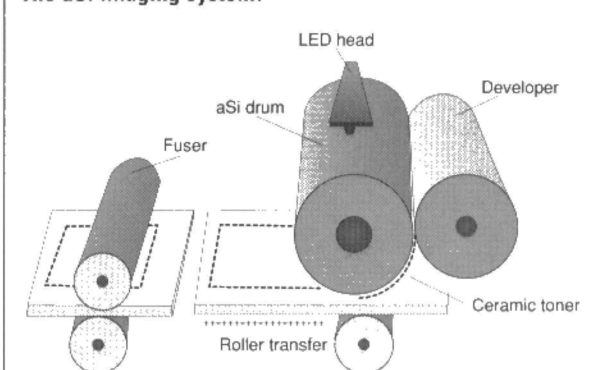
The basic machine measures 345.44 x 220.98 x 350.52mm.



The Ecosys with all its add-ons.

Able to produce 10 pages per minute at a rough cost of 3 times less than the equivalent laser printer, the FS-1500A can be said to be reasonably eco-friendly. In fact, Kyocera has named the printer the Ecosys aSi and the toner Ecotone. All of the standard computer interfaces and a number of emulations are available, from Macintoshes and PCs to Unix networks and token rings as well as Kyocera's own Postscript compatible page description language KPDL. ■

The aSi imaging system.



The Tides They Are A Changin'

John Becker comes to the aid of all those sailors who find reading tide tables a tedious business with a gadget to indicate when they will be in and when they will be out.

The period between successive high tides is principally dictated by the gravitational pull of the Sun and the Moon. Although the total pull of the Moon is less than that of the Sun, its tidal effect upon the Earth's oceans is greater since it is much closer. The average period of revolution of the Moon around the Earth, known as the sidereal month, is 27 days 7 hours 43 minutes and 11.5 seconds. However, because the Earth moves around the Sun, it takes 29 days 5 hours 5 minutes and 35.8 seconds for the Moon to achieve the same phase, a period known as the synodic month.

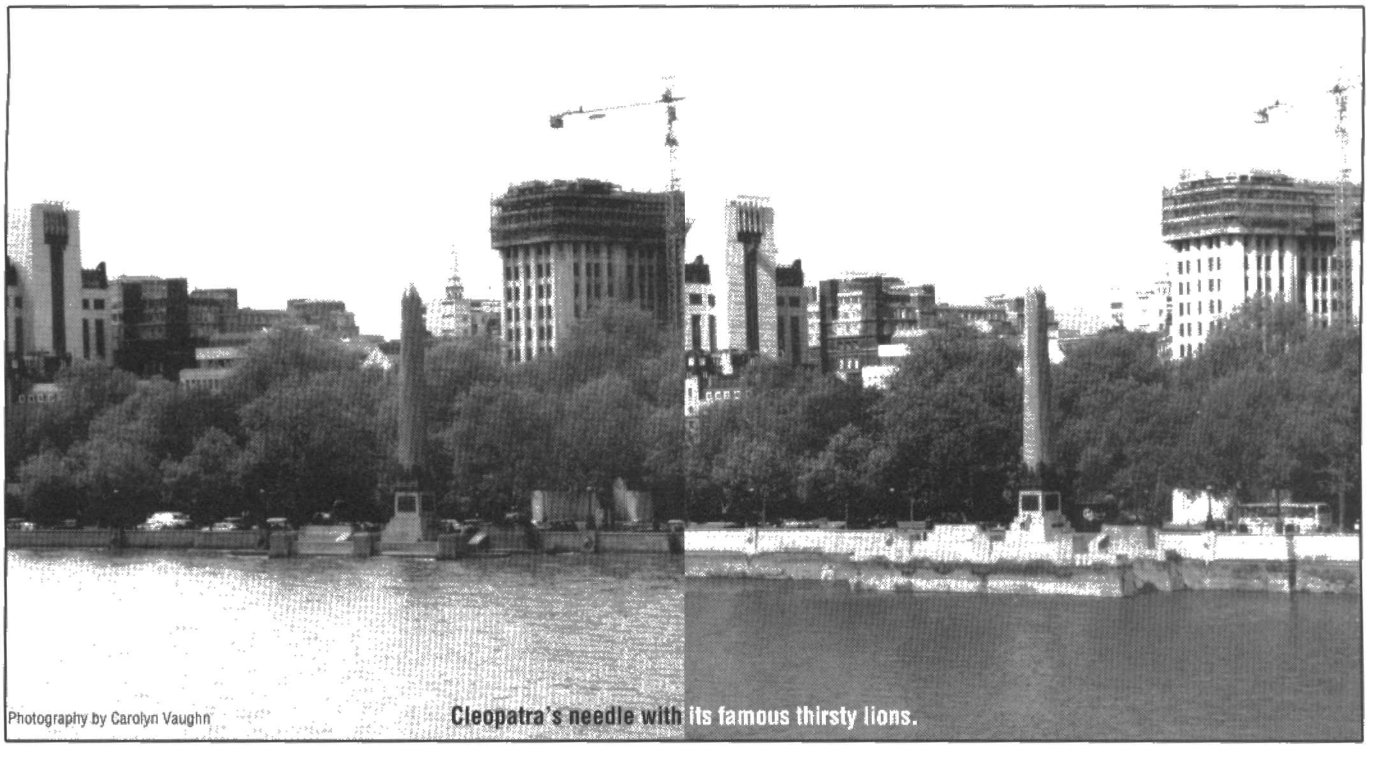
For the sake of simple tide predictions, the affect of the Sun's pull can be ignored and the length of the lunar day taken as approximately 24 hours 50 minutes, resulting in an interval of 12 hours 25 minutes between successive high tides. Another way of expressing this is to say that the time of high tide at any place is about 50 minutes later each day.

The tide meter described here is basically a crystal-controlled clock whose full cycle is timed for 12 hours 25 minutes 4 seconds split into 16 equal parts. Light emitting diodes (LEDs) monitor each of the 16 parts and are mounted as two groups of eight, representing the state of the rising and falling tides respectively as a moving dot display. A third group of eight LEDs displays subdivisions between each sixteenth part in a binary format. The circuit includes reset and fast-forward controls to set the timer to suit any tidal location. An additional switch allows the display to be incremented by up to 16 steps without changing the basic timing period. Since each step represents approximately one day's tide change, predictions of future tide states can be made.

The Circuit

Fig.1 shows the block diagram for the complete tide meter, and its circuit implementation is shown in Fig.2.

A master clock frequency of 32768Hz is generated around a series of invertors within IC4 in conjunction with the crystal, C1, C2, R5 and R6. IC4 also contains a 24-stage binary ripple counter with 16



Photography by Carolyn Vaughn

Cleopatra's needle with its famous thirsty lions.

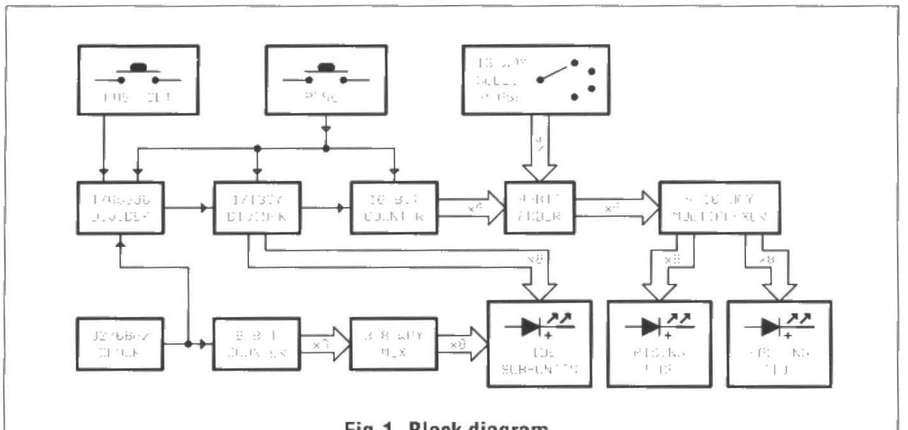


Fig.1. Block diagram.

stages selectable by a binary code applied to its A-D inputs. An additional control input, pin 6, allows the first eight stages to be bypassed. The chip is programmed to divide the crystal frequency by 65536, resulting in an output frequency of 0.5Hz at pin 13. The next part of the circuit, commencing with the 12-stage binary counter IC5, divides the 0.5Hz frequency by 1397 to produce a pulse repetition rate of 46 minutes 34 seconds. Seven outputs of IC5, corresponding to the logic 1 states in the binary code 10101110101 (decimal 1397), are connected to the 8-input NAND gate IC6. When these outputs are all clocked high, the output of IC6 goes low and via NOR gates IC7c-a is inverted to reset the counter.

The reset pulse also clocks the 4-bit counter IC1a, whose outputs are added by IC2 to a 4-bit binary offset code set by the hex switch S1. Each step of S1 has the effect of incrementing the basic code by the equivalent of 46 minutes 34 seconds, a period close to the nominal daily tide delay time of 50 minutes. The resulting output sum provides the address code to the multiplexer IC3, determining which of its 16 outputs is set high, leaving the other outputs set low. The outputs are connected to two blocks of eight LEDs within LM1 and LM2. Since only one LED can be active at any time, their outputs are commoned into the single load resistor R10.

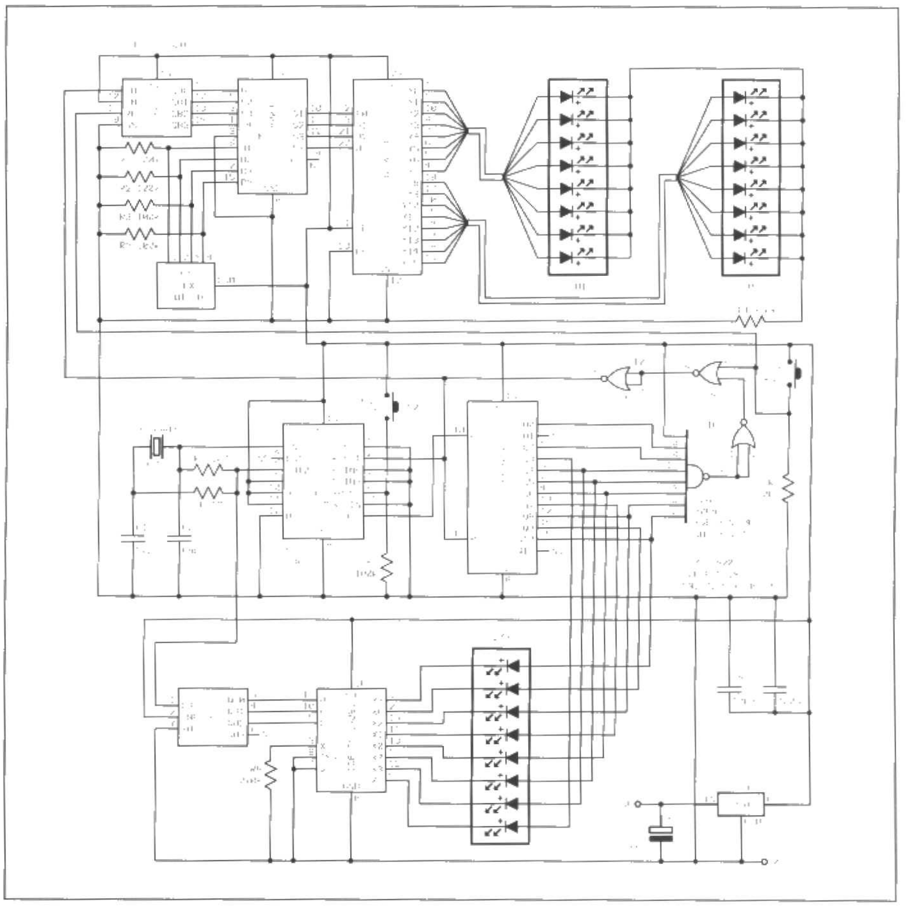
Eight additional LEDs, within LM3, display the count status of IC5 between each reset pulse, monitoring the highest eight outputs. To minimise current consumption, the LEDs have their outputs connected to the multiplexer IC8 which is cyclically clocked to sink current from only one LED at a time. The multiplexer addressing is controlled by the outputs of the 4-bit binary counter IC1b, which in turn is clocked by the 32768Hz output of IC4. R8 sets the LED current load, and thus the brilliance.

The circuit is powered by 9V DC via the 5V regulator IC9.

Practicalities

Figs.3 and 4 show the printed circuit board component and track layouts. For compactness, 10-way LED modules were used on the prototype, ignoring the extra two LEDs. Individual LEDs may be used instead if preferred. The switches are the PCB-mounting type. It is recommended that sockets should be used for all ICs and for the LED modules. The 0.3 inch wide 24-pin socket for IC3 is made up of one 16-pin and one 8-pin socket.

Setting the unit's timing for a specific location must initially be done in conjunction with a tide table. Complete national tide tables are available from sources such as ship's chandlers or scuba diving suppliers. Selected tables are also published in some newspapers, such as the Times, and also in the AA Motorists Handbook. The easiest way of setting the unit is to find out the time of low tide on a specific day and then press the reset switch S3 at that time. Alternatively, calculations can be made for setting the unit at other times by making use of the incremental switch S1 and the fast set control S2. The latter causes the first eight stages of the divider in IC4 to be bypassed. The LEDs should then be observed, releasing S2 when the correct display is seen. Once set, the unit will continuously provide an approximate indication of the varying tide states until switched off. ➤



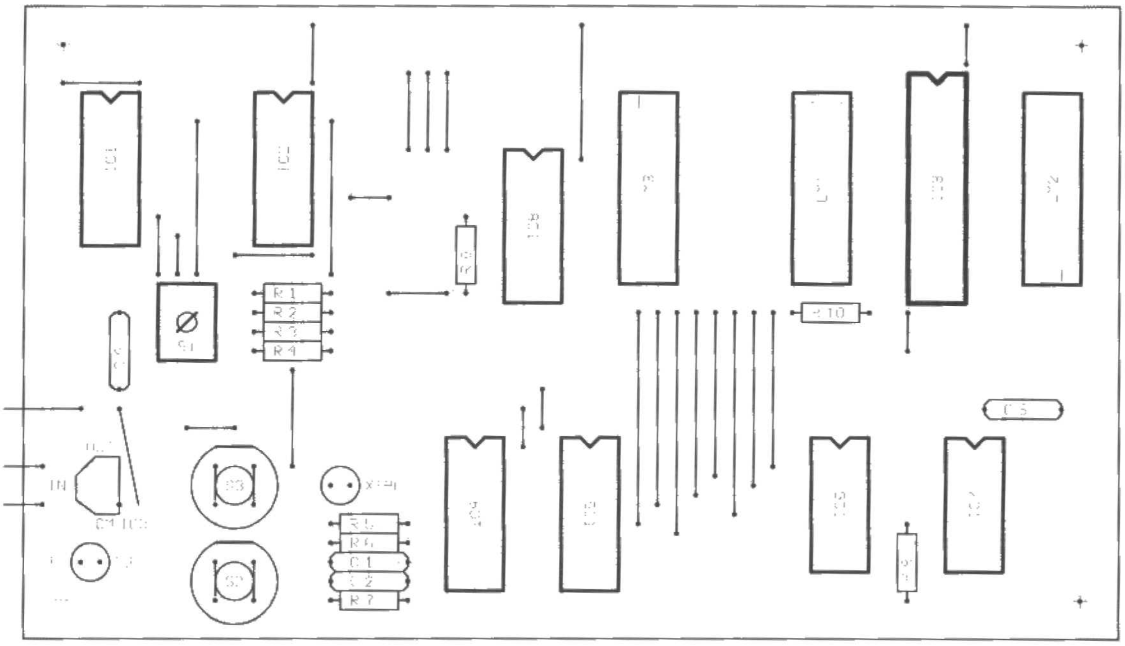


Fig.3. PCB component layout

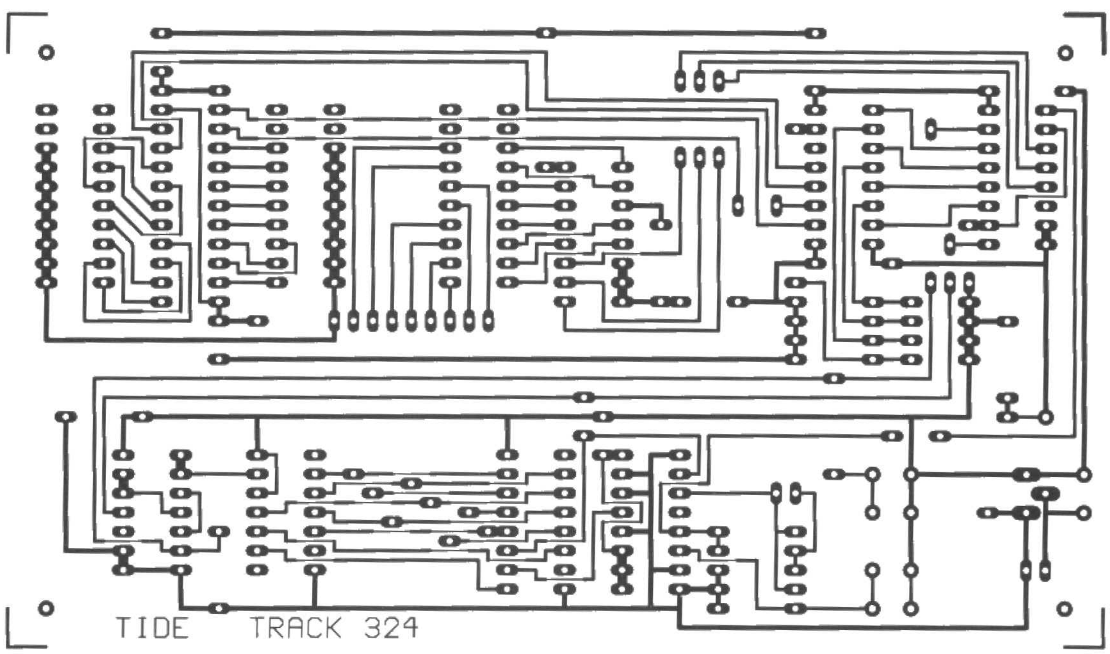


Fig.4. PCB track layout

Components

Semiconductors

IC1	4520
IC2	4008
IC3	74HC4514
IC4	4536
IC5	74HC4040
IC6	4068
IC7	4001
IC8	74HC4051
IC9	78L05
LM1-LM3	10-way DIL LED module

Resistors

R1-R4, R7, R9	100k
R5	10M
R6	1M
R8	270R
R10	470R
All	0.25W 5% or better

Capacitors

C1	22p polystyrene
C2	68p polystyrene
C3	22µ 16V electrolytic
C4, C5	100n polyester

Switches

S1	PCB-mounting 4-bit hex switch
S2, S3	PCB-mounting push-make switch

DIL IC Sockets

20-way x 3
16-pin x 6
14-pin x 2, 8-pin

When The Chips Are Down

Mike Sanders' final article on semiconductor manufacturing looks at how chips are checked out after they have been broken up.

Each stage of the semiconductor manufacturing process is checked to ensure success with some checks being more involved and rigorous than others.

Some of the things that require checking are the depth of diffusion or ion implants and the thicknesses of oxide or metal layers.

Sheet Resistance

The sheet resistance of the wafer in ohms per square metre is an indication of the amount of dopant. A common setup for measuring sheet resistance consists of four probes as shown in Fig 1. The probes are spaced 40 mils or 50 mils (1000 micrometers or 1250 micrometers respectively) part and are made of osmium with current being applied to the outer probes. The drop in voltage is measured by the inner probes and the sheet resistance is given by

R = 4.53 V/I

where I is the current and V the voltage

The equation is simple and applies only to very thin sheets which, theoretically, extend to infinity. For a probe spacing of a millimetre a correction factor must be applied if the thickness is greater than 600 micrometers and for a probe spacing of 1.25mm, a correction factor is required if the thickness is greater than 750µm. In addition to this a correction factor is required because the sheet does not extend to infinity. The equation also assumes that the layer is doped uniformly. If the doping results in non-uniform layers then resistance obtained is an average.

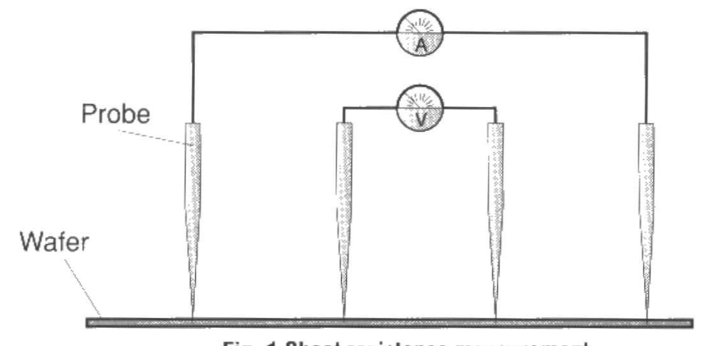


Fig. 1 Sheet resistance measurement.

Diffusion

The depth of the diffused layer is the distance in µm at which the concentration of the dopant equals the concentration of the surroundings. In order to asses the depth, a slice is taken from the wafer, fig 2. The angle of this this can be anything between 1 degree and 5 degrees, the smaller angle being used for shallow junctions, which provides better resolution.

The exposed slope is stained with a solution of hydrofluoric acid diluted to 49%. Hydrofluoric acid on its own may be used or a little nitric acid may be added.

The stain is applied under a bright light for two minutes and results in P-type regions showing up darker than N-type. When the junction is adequately stained, the specimen is examined with focused, monochromatic light fig 3. This throws up interference fringes which give the depth through the formula:

Depth = l/2 n

where l = wavelength of the light and n = number of fringes

The diffusion profile is usually know – it may be a Gaussian distribution, of Irwin's curves. However for shallow junctions and high doping concentrations, these simple methods will not give accurate results.

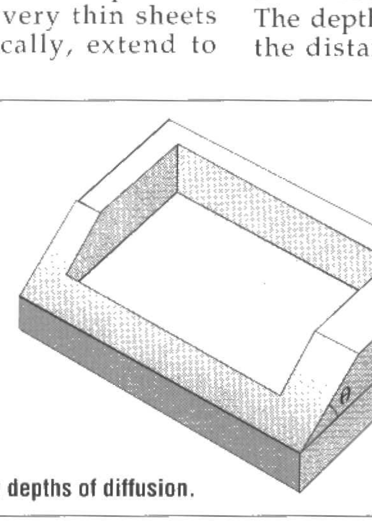


Fig. 2. Investigating depths of diffusion.

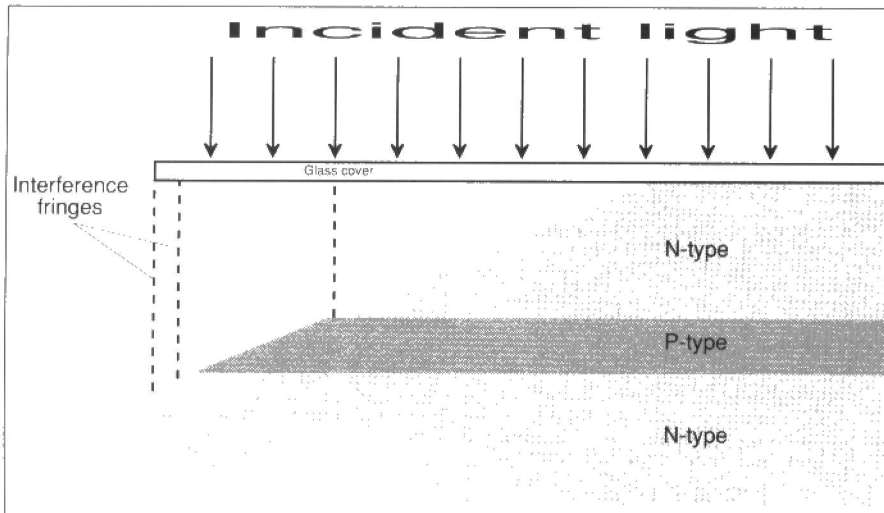


Fig. 3. Fringe measurement.

Fig. 4a. Parallel current flow.

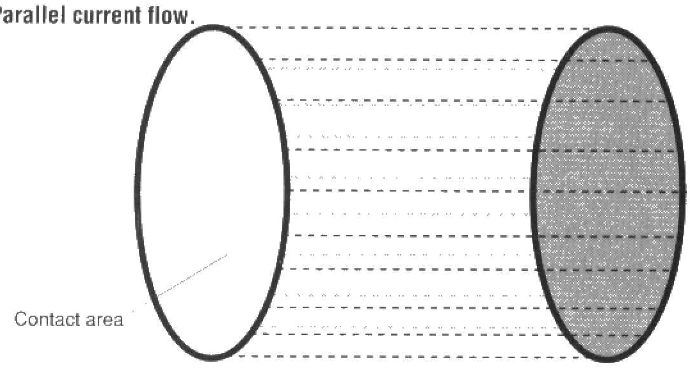
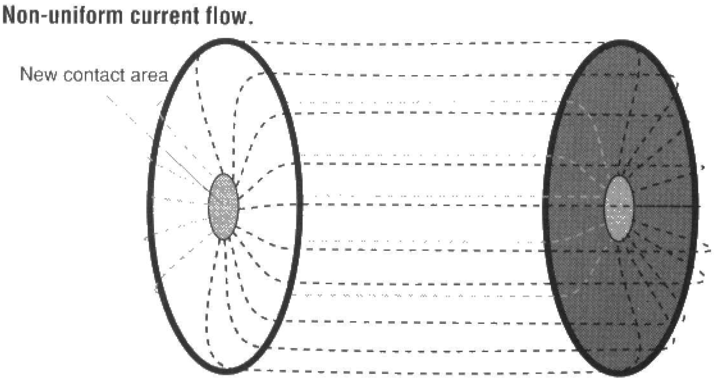


Fig. 4b. Non-uniform current flow.



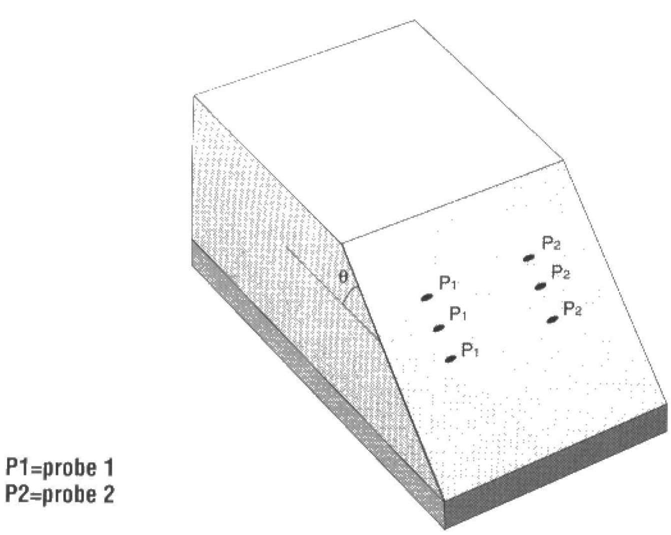


Fig. 5. Spreading resistance measurement on a bevelled edge.

If a more detailed study of the diffusion profile is required, capacitance-voltage or spreading resistance measurements are used. The first works on the principle that the capacitance of a reverse biased depletion layer decreases as the layer goes deeper into the semiconductor. Since the depletion layer depends on the concentration of impurities, the capacitance in turn depends on the number of carriers, the dimensions of the capacitor and the bias voltage.

The concentration of dopant can be measured to within a few tenths of a micron from the surface when the capacitance is plotted against the bias voltage. The depth to which the measurement can be carried out is not great and a dopant concentration of 10^{13} atoms/cm^3 to 17^{127} atoms/cm^3 is about the limit.

Spreading resistance measurements can be explained by first considering a wire of length 1 and radius r. The resistance is given by: $R1 = pl/\pi r^2$

where p is the resistivity.

If the contacts placed at each end of the column of wire are decreased in area so that they do not cover the end surfaces, the resistance increases and the current does not flow parallel to the axis as it did before, fig 4a.

Instead the flux lines are as in fig 4b. The resistance is now:

$R2 = 2n$

where n is the new radius.

Incidentally, the contracts can be side to side and do not have to be at opposite ends of the wire. The following is the measurement method used:

A bevel is cut in the wafer Fig 5 – the angle varying between 0.1 degree and 10 degrees depending on the resolution required. The alloy probes are then pressed against the bevel with a pressure of about 10 grams. The probes are spaced 10μm to 100μm from each other and several measurements are taken at different distances from the edge of the bevel.

The results are of net carrier concentration in relation to depth and not doping concentration in relation to depth.

Other methods for measuring the doping concentration are differential conductivity and secondary ion mass spectroscopy (SIMS). A comparison of the various systems is shown in Fig. 6.

Method	Limitation	Remarks
Capacitance-voltage	10^{13} to 10^{17} atoms/cm^2	Surface resolution not good
Differential conductivity	10^{18} to 10^{20} atoms/cm^2	Surface must be etched
Spreading resistance	$\approx 1\mu m$ depth	Requires bevel
SIMS	$\approx 0.1\mu m$ depth	Standard required

Fig. 6. Comparison of methods of measuring the diffusion profile.

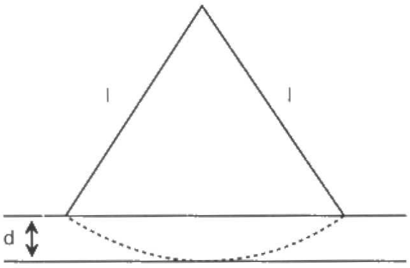


Fig. 7. Pit etching.

The Epitaxial Layer

The parameters of interest are the thickness and the doping concentration. The main methods for measuring thickness are angle lap and stain, pit etching and infra-red interference.

Pit etching is illustrated in fig 7 where it can be seen that the defects at the boundary between the epitaxial layer and the substrate extend to the surface. If the pit is etched along these lines, the depth of the epitaxial layer for 111 silicon is related to the length of the sides by the equation:

$d=0.816l$

The infra red spectrophotometer is the third method of measuring thickness and can also carry out analysis of oxygen and carbon content. For this reason the method has gained importance. It was first described by Tanenbaum and Spitzer and employs an infrared beam focused at an angle of about 15° on the surface of the epitaxial layer – Fig 8.

At the top surface of the epitaxial layer the beam is split into a refracted ray and a reflected ray. The first continues on to the bottom of the epitaxial layer where it is reflected.

Constructive or destructive interference occurs between the refracted ray at point x and the ray exiting at point y, depending on the difference in the optical path. If the difference is an odd multiple of half wavelengths, a minimum will occur and if the difference is an even multiple of half wavelengths a maximum occurs.

For sheet resistance measurement, layers of silicon wafer are removed by etching or onodic oxidation. The sheet resistance of each new surface is measured and, in this way, the impurity profile versus depth can be computed.

In the reverse-bias CV method a Schottky barrier diode is formed by placing a metal on the wafer. The diode is reverse biased and the capacitance-voltage relationship is plotted. The impurity concentration is then obtained mathematically.

A mercury probe is often used for CV plotting as shown in Fig 9. The mercury acts as a probe as well as forming the Schottky diode. The probe is applied to the wafer and mercury siphoned through the probe. The area of contact with the mercury is calculated by measuring the capacitance of an oxide layer of known thickness.

Oxide And Thin Films

The parameters of interest here are the thickness, breakdown voltage and levels of contamination. There are many methods of measuring thickness such as reading colour charts, interferometry, CV, profilometry and reflectometry. Yet another method of measuring the thickness of a conductive film is to place it between two RF coils and measure the change in Q factor of the circuit.

If colour charts are used then it is necessary to know all the previous colours since the colours repeat themselves. Therefore, the wafer is dipped in hydrofluoric acid and removed slowly. This etches a taper in the oxide layer – Fig 10. When the uniform layers of oxide are examined under perpendicular white light, they reflect colours as shown in the partial colour chart of Fig 11.

In the CV method, two conductive plates of known area are placed with side of the material and capacitance measure from which thickness can be calculated.

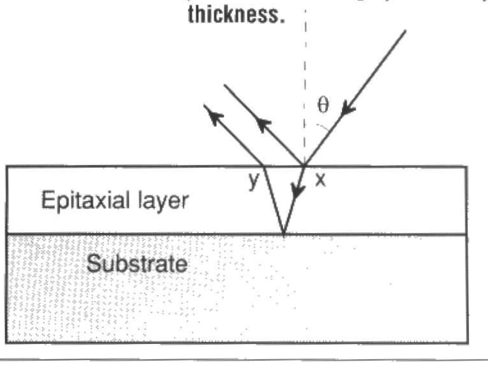
One of the most direct methods of measuring film thickness is to mask off part of the substrate when the film is deposited. This provides a step which a surface profilometer can measure. The profilometer consists of a stylus which is drawn across the step. The electrical output of the stylus is amplified and drives a pen recorder and a pictorial trace is obtained. With this method, steps as small as 100 Angstrom can be measured accurately.

One of the most accurate methods of measuring oxide thickness is to use an ellipsometer. The accuracy provided by this instrument is required only rarely as when measuring the thickness of gate oxide in MOS devices. The instrument reflects monochromatic, polarised light off the surface of the film and then analyses the reflected light for changes in polarization, phase and intensity. A set of Fresnel equations then have be solved making this method accurate but complex and expensive.

The breakdown voltage of a dielectric is found by placing a dielectric of known thickness between two conducting plates. The voltage between the two plates is increased until the current between the plates rises rapidly. For silicon dioxide a breakdown voltage of 600V per µm is good enough.

The level of contamination, mainly by sodium, is measured by a capacitance-voltage technique.

Fig. 8. Infra red techniques for measuring epitaxial layer thickness.



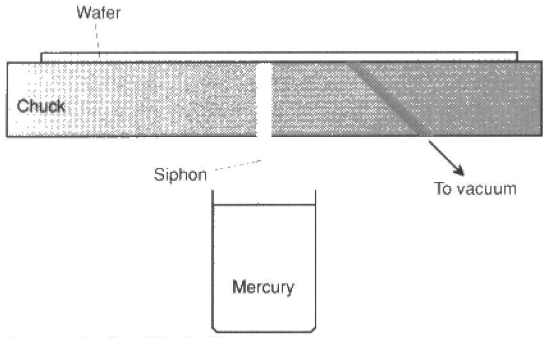


Fig. 9. Measuring probe for CV plotting.

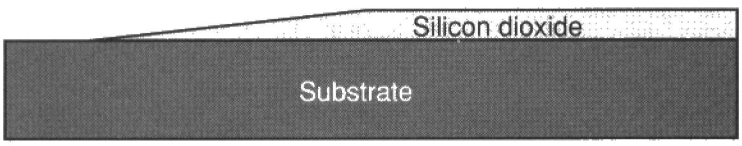


Fig. 10. Etching and taper in an oxide layer.

Conducting plates are placed each side of the silicon dioxide, a voltage applied and the capacitance measured – Fig 12. The voltage is then reversed and the voltage-capacitance graph is plotted again. The difference between the two curves shown the presence of contaminants.

Ion Implants

The most common methods of checking the dosage of ion implants are:

- The four point probe for resistance measurements
- The CV method
- Spectrometry
- Optical dosimetry

The first three methods have already been covered. The optical dosimeter measures both the does as well as uniformity of ion implants. A transparent piece of glass acts as the wafer and is coated with positive resist which is exposed to ultra-violet light to make it transparent. The glass is then placed in ion implanting chamber and irradiated. It is then presented to the optical dosimeter and the transparency across the wafer is plotted. This is compared with the plot before implantation, making allowances for the characteristics of the photoresist, allows the uniformity of the implant can be derived.

Metallisation

The metal layer can be checked for thickness by the surface profilometer and stylus. An alternative method is to use a quartz crystal resonator plate. This is located in the deposition chamber and the changes in frequency calibrated against the mass of metal deposited on the plate.

Since the mass of metal plate deposited and its are known, the thickness of film can be calculated. Once the resonance monitor is calibrated, the instrument is ready to use in situ for controlling not the thickness of the film but the rate at which the metal is deposited.

Silicon Trends

The use of larger wafers and a higher density of chips on the wafer has brought the cost of integrated circuits down.Because of the rapid changes, the industry has had to adapt to new technologies every few years.

For a start, the larger wafers are treated in the same uniform manner as the older smaller ones if the yield is to be maintained. A bigger wafer also means that the thickness must be increased to prevent the wafer from breaking. However the cost of processing a larger wafer is only marginally greater than that for smaller.

Then there is the purely physical side. Starting with 4in diameter wafers in 1980s, the size was up to 6 inches by 1985 and the automatic loaders had to be upgraded.

The photomasking process is also starting to reach the limit of its technology. A practical limitation is the gap between the mask and the wafer caused the mask or wafer not being flat or any particles trapped in between them.This gap causes light to diffract or bend which means that the edge of the exposure is not where it should be. If all conditions are perfect, the minimum length that can be printed is between two and four times the wavelength of the light source. Therefore if a mercury arc lamp is used, for instance, emitting 4000Å, the minimum length printed will be between 1μm and 2μm.

Since the wavelength place a limit on the smallest shape that can be copied an obvious answer is to reduce the wavelength. X-rays of wavelength 5Å to 15Å can be used.

However, because X-rays do not travel far in the atmosphere, the masks have to be exposed in a vacuum. This means that although X-ray exposures have been used in the laboratory, they have not been implemented to any large extent in the factory.

Another method of overcoming the wavelength limitation is to use a beam of electrons to scan the wafer with the resist being exposed wherever the electrons strike it. Electrons may be considered as charged particles possessing properties of waves with a wavelength of less than one Å.

When an electron deflection system such as is used in a cathode ray tube is used in conjunction with an election microscope, the high magnifications required for today's densely packed chips are obtained. In addition, a mask is not required since a computer can be linked to the scanner which will not only make the electron beam scan but

Thickness of film in μm	Colour
0.05	Tan
0.075	Brown
0.100	Violet
0.125	Royal blue
0.150	Metallic blue
0.175	Light yellow
0.200	Light gold
0.225	Yellow orange
0.250	Melon
0.275	Red violet
0.300	Blue violet
0.310	Blue
0.325	Blue green
0.345	Light green
0.350	Yellow green
etc	

Fig. 11. Partial colour chart.

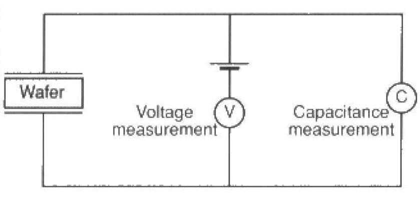


Fig. 12. Checking for contamination.

also turn it on and off.

The electron scanner can also be used to produce masks. The step and repeat process used with optical devices is no longer required since the scanner is able to map out the whole make at one pass. Although the scanner is used commercially to produce masks, it is not used outside the laboratory to transfer images onto the wafer itself. This because the method is slower than conventional methods and requires considerable skill. However, technology has a habit of growing out of the laboratory and into the workplace as instrument get faster, cheaper and operators become more skilled.

Other processing areas are also showing definite trends. Not only is uniformity required over a larger surface areas but also in the vertical plane. This means thinner epitaxial layers. For etching, dry etching is used predominantly for sizes below 3µm. For wafers larger than 100mm diameter, ion implantation is favoured over other techniques of impurity introduction.

In the metallisation process, there are moves to replace aluminium with other metals like tungsten which is better able to tolerate the high temperatures during processing. Other metals are silicides and polycides. The former is a compound of silicon, tungsten and molybdenum, the latter is a compound of poly-crystalline silicon with tungsten and molybdenum.

Oxide layers need to be thin as well as have a high dielectric strength particularly in the gate oxide layer. For protection, the silicon dioxide on top of the wafer is being replaced by polymers like polyimide which is spun on or a plasma of nitride.

Non-Silicon Technology

No description of semiconductor manufacturing techniques would be complete without a mention thick and thin films.

Thin film circuits resemble old style copper printed circuit boards. They are made by depositing a thin metal layer on a substrate by vacuum deposition. Then the metal is covered with photoresist which is dried and exposed to light. The metal is now etched to the required pattern. Components such as transistors, diodes, resistors and capacitors are then mounted as necessary.

Thick film technology on the other hand contains passive devices like capacitors and resistors as part of the film. The film paste is placed on an alumina substrate by a stencil screen printing method. This is then baked in a furnace and the component produced depends on the composition of the paste.

The practice of producing a substrate film to which other components are connected as opposed to a fully integrated circuit, is referred to as hybrid technology. It allows the designer a freedom to put together a circuit choosing components that have the required characteristics rather than being stuck with, say just TTL or just CMOS.

Thick film circuits are easier to manufacture than thin film circuits but the applications are limited to frequencies of around 1GHz. Thick film resistors have a maximum of 5Mohms with tolerances around ±1%. Therefore for higher frequency or more precise operation, thin films are used.

ICs In Brief

Pure silicon is refined from sand and grown into large crystals using float zone and Czochralski methods, the latter being the more popular.

The crystal is then sawed into thin slices called wafers after determining the axes from the Miller indices. Epitaxial layers are deposited by chemical vapour deposition (CVD) process in one of three types of chamber, horizontal, vertical or barrel.

Various gases can be used as a carrier, the dopant or merely to flush out the chamber. Modern CVD processes use a combination of temperature and pressure to achieve the best film quality.

The semiconductor manufacturing process results in may lethal products which must be treated before release into the environment.

Layer of oxide can be placed on the wafer with an oxidation process using either water or pure oxygen at temperatures between 900C and 1300C.

Component patterns are placed onto the wafers by means of a photolithographic process using photoresist, masks and etching.

After this impurities are introduced into unoxidised areas of the wafer by diffusion and ion implementation. The circuit components are then interconnected using aluminium. This is deposited using either filament evaporation, electron beam evaporation, flash evaporation and sputtering.

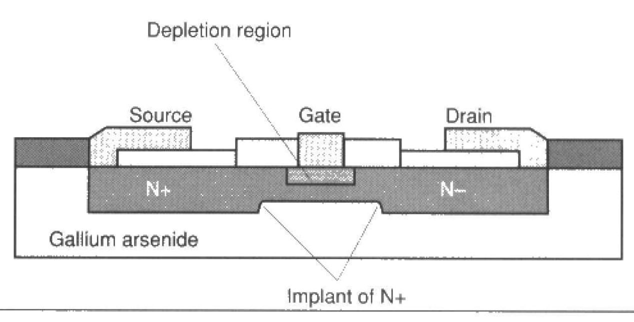
Devices are manufactured using two main technologies, bipolar and MOS. Resistors, diodes and capacitors are also included on an integrated circuit.

Testing is carried out throughout the manufacturing stages and sheet resistance is a measure of the amount of dopant. Other methods of measuring depth of diffusion are the stain a bevelled edge, CV measurement and spreading resistance measurements.

Similar methods are used to examine oxide and metal layers. In addition a check on the dielectric strength is carried out on the oxide layer.

It will be interesting to see what the future brings as demand grows for more and more concentrated chips. Techniques found currently in the laboratory will migrate into the factories and new ideas will emerge as experiments continue. ■

Fig. 13. Depletion mode MOSFET.



Techniques

Andrew Armstrong with a programmable solution to a flashy question.

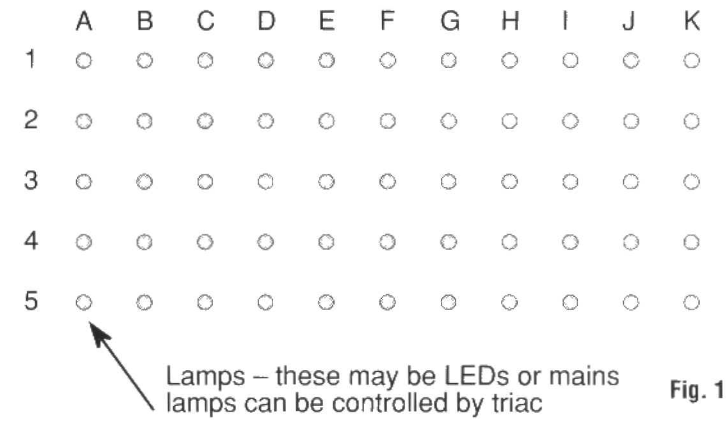


Fig. 1.

A reader from Ilford in Essex (I used to live there before they flattened it) would like a design to control a panel of lights, as shown in Fig 1. He wants a sequence of dynamic patterns as follows:

1) Vertical bar running from left to right.
2) Vertical bar running from right to left.
3) Horizontal bar running from top to bottom.
4) Horizontal bar running from bottom to top.
5) Negative (ie all leds alight except the bar) vertical bar running backwards and forward between the two ends.
6) Alternate pairs of columns flash.

Because there are five rows and eleven columns, sixteen control lines can be used to select any individual LED or any row or column. Any led whose row and column lines are energised illuminates. To illuminate any other pattern by using row and column addressing would require multiplexing, but luckily all the patterns requested use whole rows or columns.

It would be possible to do this with discrete logic, but the circuit required would be complex. The most obvious discrete logic approach uses an EPROM to store each light pattern in a sequence in pairs of bytes, with low order address lines used to cycle round the sequence. The least significant address line would be used to select the two parts of the sequence.

Higher order address lines would be used to select which sequence was in use. Two clocks are required, one to time the individual steps in a sequence, and one to time the duration of each sequence. One snag which would need to be addressed (pun intended) is that not all sequences are of the same length, so that a simpleminded cycling round a section of memory might not be suitable. Perhaps the sequences could be redesigned to suit, but this approach is limited in its versatility.

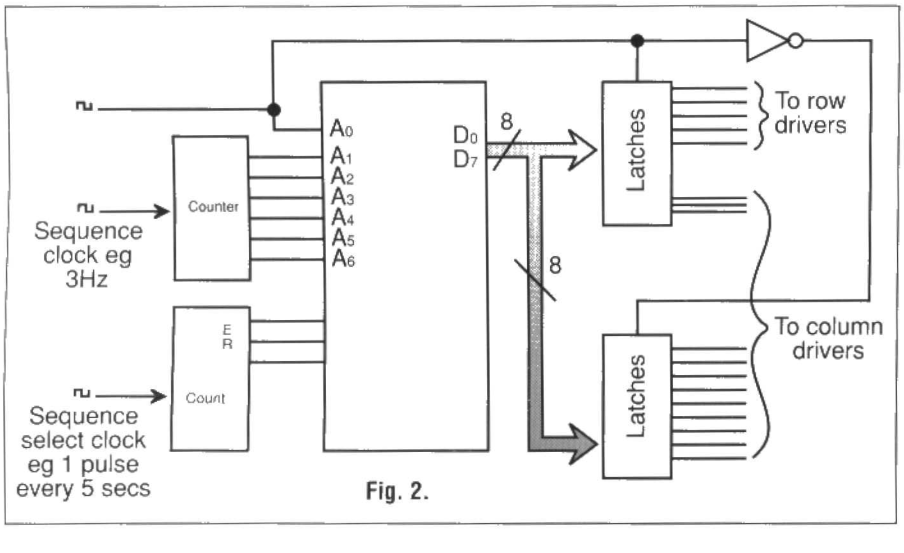


Fig. 2.

For the sake of interest, a block diagram of this approach is shown in Fig. 2.

Microprocessor

Discrete logic not using an EPROM is even less versatile, as well as being complicated. It may be that after seeing the patterns one would wish to alter them to produce a more pleasing effect. With discrete logic this involves redesigning the board, while, with a microprocessor system, re-writing a few lines of code will suffice.

A representative circuit diagram of such a system is shown in Fig. 3. The 80C31 microprocessor is ideal for this sort of small control application, and is shown here used with a separate EPROM which stores both the program and a table of patterns. The design as it is shown here can control each lamp individually, so that control is no longer confined to horizontal or vertical bars.

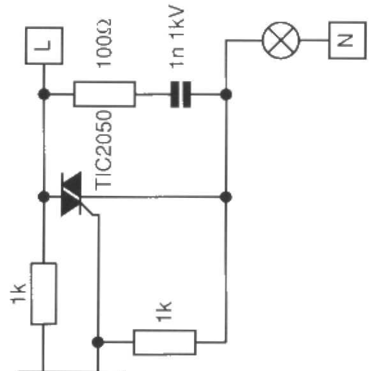
Only one output is shown, but there are eight outputs on each 74HC374 latch, and there are a total of eight latches in the system. This would allow control of up to 64 lamps, though in the reader's example only 55 are required.

Lamp pattern data for a group of eight lamps is output to the address/data bus and latched into the appropriate 74HC374. The

appropriate latch is selected by the 74HC138 3-line to 8-line decoder, which is fed from the lowest three address lines. When it is time for data to be rewritten to the latch, the 74HC138 outputs are strobed by the write line from the microprocessor.

The sequence rate is set by an external oscillator fed in on an interrupt input. This represents the simplest way to provide an adjustable speed. The output is controlled via an opto-isolator which requires 10 mA through its led if it is to be guaranteed to switch. If a different isolator is to be used, then the value of the limiting resistor must be recalculated. In any event, take care not to exceed the output current rating of the 74HC374. A suitable power supply design is shown in Fig. 4. Only one decoupling capacitor is shown, but probably a couple of others should be scattered around the board at convenient places.

If only bar mode lamp driving is required, and no extra versatility will ever be required, then the cost of a separate opto-isolated triac and power triac for each output is probably not justified. In this case,



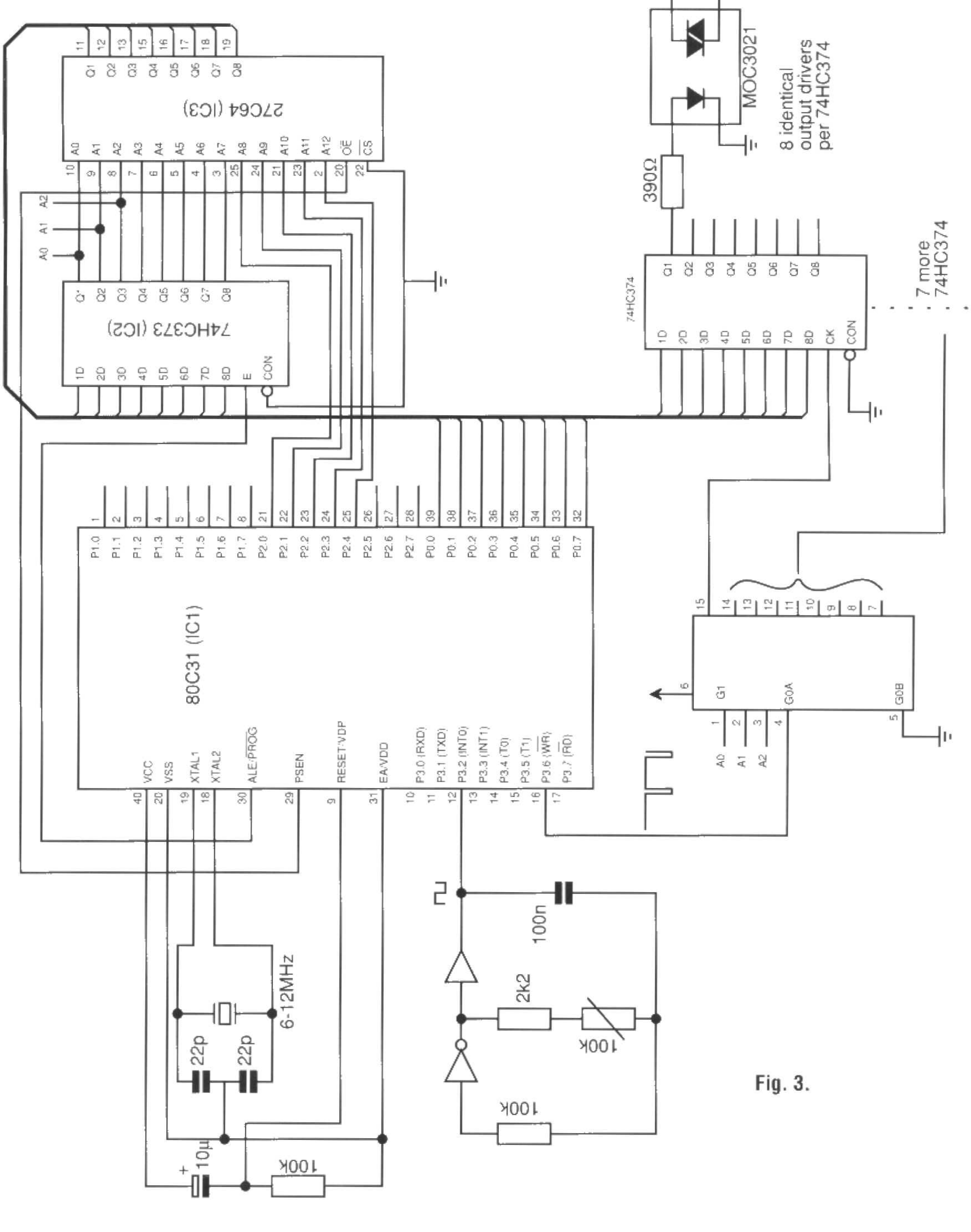


Fig. 3.

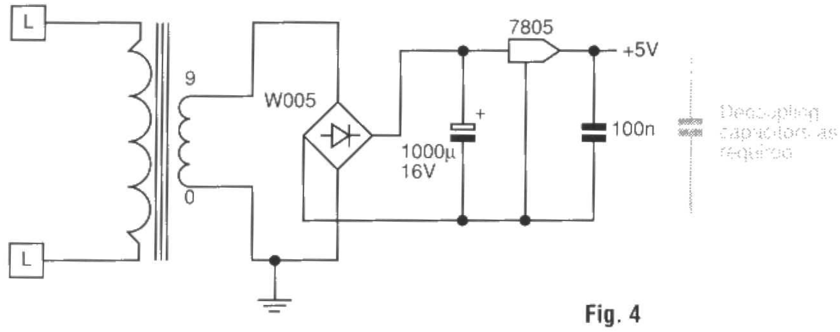


Fig. 4

the circuit illustrated in Fig. 5 may be used. Both ROW and COLUMN triacs must be switched on in order to illuminate a given lamp, so that for a vertical bar, one column driver and all row drivers would be on.

Because the triacs each switch a number of lamps, higher current types should be chosen. Just add up the load current for each lamp, double it to cope with surges, and choose a triac of that rating.

If only LEDs are to be driven, then power MOSFETs can be used to control them. If a small low current display is to be constructed, the output drive from the 74HC374s may be sufficient, but most practical applications will require more current. If only bar mode is to be used, P-channel FETs may be used to drive the columns from the positive supply, and N-channel FETs to drive the negative. In this application, a higher current power supply (probably switched mode) will be necessary.

The Program

In line with normal policy in Techniques, this program is not intended to be perfect as it stands, but it is intended to show how the job should be done. The first instruction, which the microprocessor executes after a reset, is a jump to the start of the main routine at 100H. This section clears internal registers, enables interrupts, then the "HERE" instruction loops to itself until an interrupt occurs.

When the interrupt (from the external clock) does occur, the instruction at address 3 is executed. This is a jump to "CLOCK", which is the start of the code which looks up the lamp positions in the tables and outputs the data to the latches as described above.

The table organisation is as follows: The first entry in each table is the first step in the sequence for a particular group of 8 lamps, with separate tables (0 to 7) for each latch/bank of lamps.

This may require some debugging, but should work more or less as shown. If the full versatility of individual lamp addressing is not required, and bar displays are acceptable, then only two tables and two latches are needed. As mentioned above, the reason for this approach would be to save the cost of one driver per lamp. ■

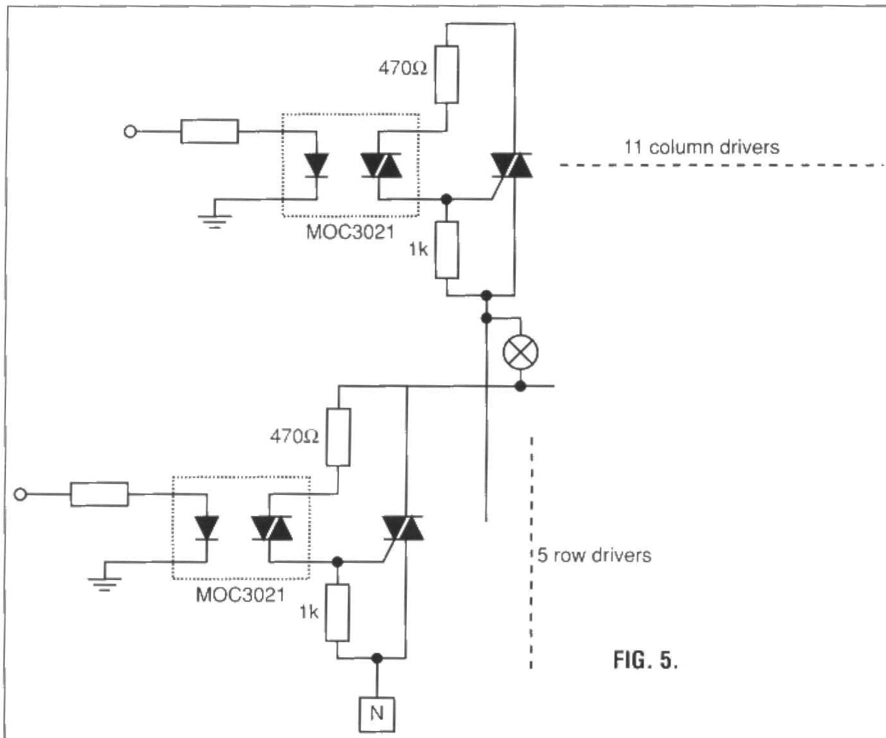


FIG. 5.

```
Address   Mnem  Operands Comments
label
CLKCNT    EQU   20H
          ORG   0           ;ADDRESS 0
          LJMP  BEGIN
          ORG   3           ;ADDRESS 3
          ORG   100H
BEGIN     MOV   SP,#40H     ;SET STACK PTR
          CLR   RS0         ;REGISTER BANK 0
          CLR   RS1
          CLR   A
          MOV   CLK CNT,A ;CLEAR COUNT
          SFTB  EX0
          SEIB  EA          ;INTERRUPTS ON
HERF      SJMP  HERE        ;WAIT FOR INT
          ORG   200H
CLOCK     CLR   A
          MOV   R0,A   ;POINT TO ADDRESS 0
          MOV   A,CLKCNT          ;GET COUNT
          MOV   R7,A              ;SAVE
          MOV   DPTR,#TABLE0      ;POINT TO
                                  ;TABLE 0
          MOVC  A,A,+DPTR ;LOOK UP
                          ;BYTE
          MOVX  @R0,A       ;OUTPUT TO 0
          INC   R0          ;NEXT ADDRESS
          MOV   DPTR,#TABLE1
          MOVC  A,A+DPTR
          MOVX  @R0,A       ;OUTPUT TO 1
; AND SO ON FOR THE NUMBER OF TABLES USED
          MOV   A,R7
          INC   A
          CJNE  A,#MAXCNT,ENDINT
                ;COMPARE WITH MAX VALUE
          CLR   A
ENDINT    MOV   CLKCNT,A  ;RESTART
          RGTI
TABLE0    DB    0F0H        ;EXAMPLE
COMMANDS
          DB    0FH         ; TO SET UP
TABLE
          DB

TABLE1    DB    0F0H
```

Continued from page 54

Philips is pitching for a share of the market for Closed Caption decoders. TV programmes in the US have subtitling for the deaf buried in line 21. The data rate is much lower than for teletext, around 0.5 MBit/s. Congress has decreed that from 1993 every TV set with a 13in or larger screen must have a built-in decoder. The aim is to force down the price of decoders from around $200 for an add-on box, to around $10 on the price of a TV set. Currently only around 100,000 decoders are sold.

Philips has eyed the potential market of 20 million TV sets a year and designed a single chip decoder for manufacturers to build into TV sets. The chip ("Litod", short for Line 21 decoder) should by now be ready. It will connect in a daisy chain with the RGB colour circuits, to give colour titles with the option of scrolling, rolling and underlining. Chip cost is put at $5 in volume. Makers of budget TV sets can make only hardware connections, without any software control of the Litod chip.

Why should all this interest us in Britain, when we already have teletext for subtitles? Because the US Litod system has one very special advantage over teletext. The data rate of the signal in line 21 is so slow that it can easily be recorded by any VCR. British teletext can only be recorded by professional video decks or tweaked Super VHS. This is why pre-recorded video tapes in NTSC format can boast subtitles for the deaf.

Finally, two personal pleas.

Can the new UK teletext service operator please do something which is blindingly sensible, but which Oracle would never do - that is to match page numbers where both the BBC and ITV/Channel 4 offer similar services. It is just plain daft to expect the public to remember different page numbers for similar services, like news, weather, sport and TV programmes.

And will the new service please do as the BBC does and make it as easy to use Fastext to check satellite programmes as terrestrial TV? ■

Taking A View On Teletext

Barry explains the concepts behind teletext and looks at some of the latest developments in the technology.

Oracle has lost the domestic teletext franchise. At the end of the year it goes to Teletext UK Ltd, a consortium which includes Philips, which bid higher than Oracle in the ITC's auction.

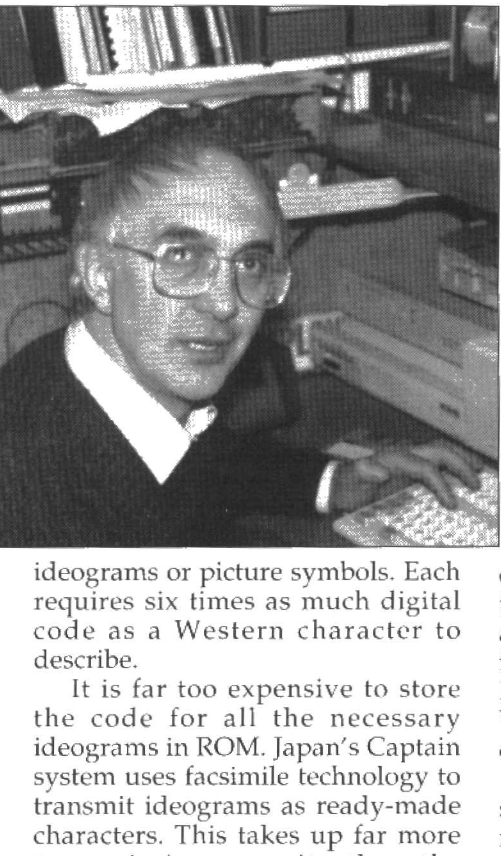
It is appropriate that Philips should get a slice of the teletext action. The first text service began in 1976 and there are now over 50 million teletext TV receivers operating in over 40 countries. Philips has supplied more than 42 million of the chip sets.

Early decoders needed over 200 IC's. Now one chip does it all. Each page needs 1 kilobyte, 8 kbits, of memory. Adding RAM chips speeds access to selected pages which are pre-selected and stored ready for call-up.

Only one market has shown no interest in the European system, which is now known as World System Teletext.

"We have failed dismally in the USA" admits Dick Bugg technical consultant to Philips' chip design centre at Southampton. "But it's not for want of trying. The last big opportunity to open new markets is in China."

The teletext signal is a stream of digital code, running at just under 7 MHz, which is transmitted in the unused lines of the TV picture which define the black borders at top and bottom of the screen. This code triggers the generation of alphanumeric characters permanently stored in ROM. Early decoders stored 96 characters. The latest can store 192, which covers all languages in Western Europe. But this is still nowhere near enough to cope with the Chinese language, which uses at least 20,000



ideograms or picture symbols. Each requires six times as much digital code as a Western character to describe.

It is far too expensive to store the code for all the necessary ideograms in ROM. Japan's Captain system uses facsimile technology to transmit ideograms as ready-made characters. This takes up far more transmission capacity than the teletext method of sending only short codes which trigger the generation of characters stored in ROM. Also the fax code is easily corrupted by transmission errors, for instance caused by reflections of the broadcast signal from buildings or hills. Small code errors cause large changes in the ideogram.

Japan has been trying to sell Captain to China, but with no success. The Chinese Ministry of Radio, Film and Television wanted a more robust system than Captain. The Ministry also said the system must be cheap enough for the masses and compatible with World System Teletext so that the TV station can broadcast pages of either Western text or Chinese ideograms, or pages containing both, to all TV sets.

Philips Semiconductors at Southampton recently came up with a solution. The transmitted signal is a mixture of conventional teletext trigger codes and ready-made patterns. The decoder in the TV set has a Read Only Memory which stores a library of the most commonly used ideograms. It also has a Random Access Memory. When the text page contains an ideogram which is not available from ROM, the transmitter converts the character into a string of dots. The receiver stores these dots in RAM which reconstructs them into a "soft character". What appears on screen is thus a mix of ideograms sourced from ROM and RAM. The ROM also contains Western characters, so the system can mix and match languages.

The more characters the ROM stores, the less time the system must waste reconstituting soft characters from RAM. But large ROM storage increases component cost. After analysing text likely to be transmitted, Philips chose 4 MBit of ROM, to store 3000 hard characters and 16 Kbit of RAM to buffer the soft characters.

The system was tested during the Asian games, held in Beijing. Philips installed 150 prototype receivers in public places to check compatibility of dual language information services. The Chinese Ministry is now recommending that the system be adopted as a broadcasting standard.

Having given up hope of turning the US market onto teletext,

Continued on page 53